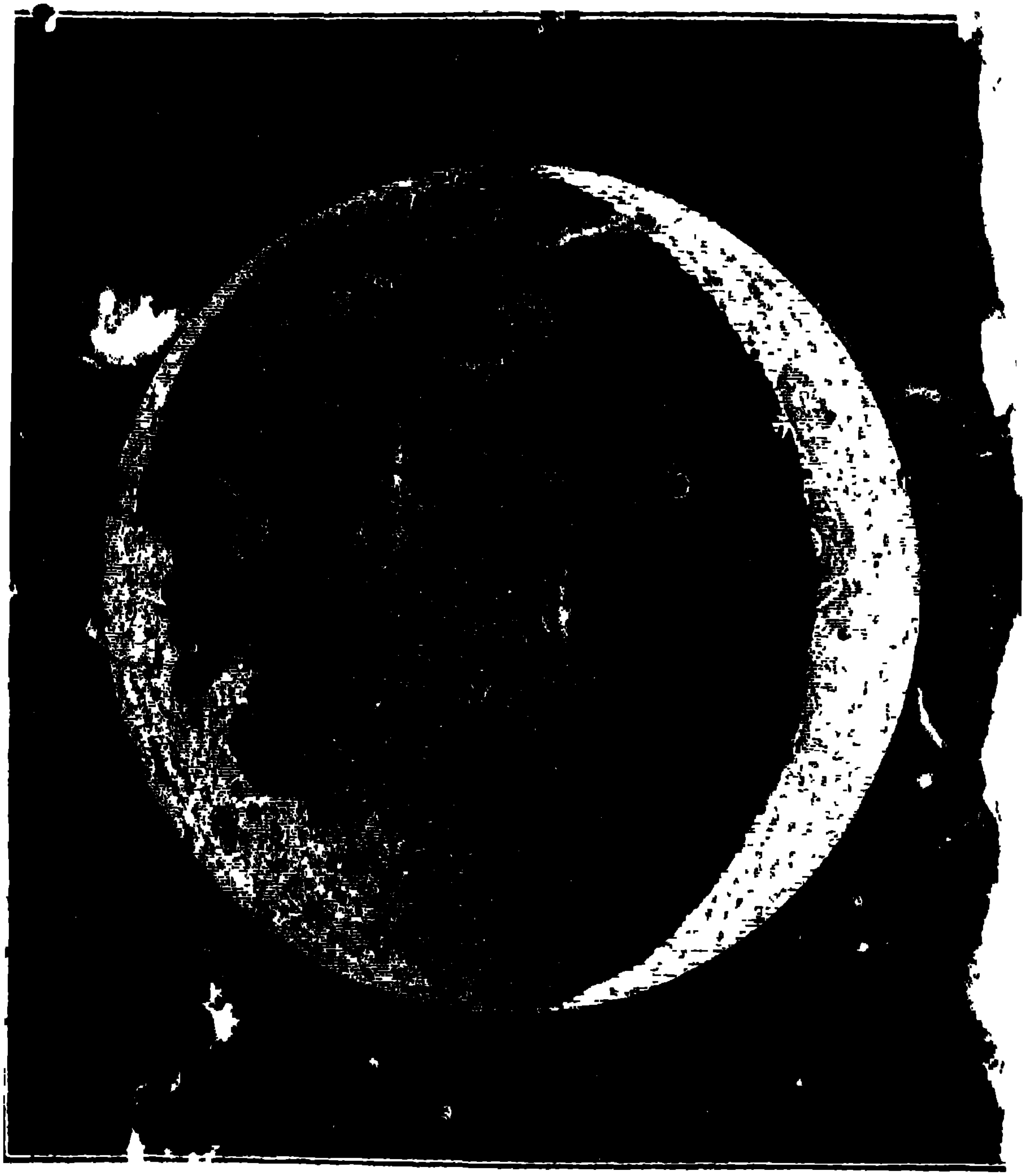
FRONTISPIECE.



——"You must now look back to my FRONTISPIECE. It shews you the Moon, as, in very clear weather, you may see it, when it is three or four days old," &c.—PAGE 94.

TALES
ABOUT
THE SUN, MOON, AND STARS

BY PETER PARLEY,

AUTHOR OF TALES ABOUT EUROPE, ASIA, AFRICA, AND AMERICA.
TALES A[illegible] CHRISTMAS, BLACK MONDAY, ETC. ETC.

WITH NUMEROUS ENGRAVINGS.

The Fourth Edition.
WITH GREAT ADDITIONS AND IMPROVEMENTS.

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M.DCCC.XLII.

"In the evening of a long toilsome life, if a man were to be obliged solemnly to declare, what, without any exception, has been the most lovely thing which, on the surface of this earth, it has been his good fortune to witness—I conceive that, without hesitation, he might reply. 'The Mind of a Young Child.'

"We observe with what delight a Child beholds light—colours—flowers—fruit, and every new object that meets his eye; and we all know, that (before his judgment be permitted to interfere) for many years he feels—or rather suffers—a thirst which is almost insatiable.

"He desires, and very naturally desires, to know what the Moon is? —What are the Stars?—where the rain, wind, and frost come from? With innocent simplicity, he asks, what becomes of the light of a candle, when it is blown out? Any story, or any history, he greedily devours."

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PREFACE.

THERE was once a city upon the coast of the Mediterranean, (says Ibrahim Califi, the Arabian biographer of Gengis Khan,) whose King bore the name of Altan. His wife was called Corlauch, and his daughter was the Princess Corecli. Such was the beauty of Corecli, that even dry wood, if she smiled upon it, immediately shot forth leaves; and if she smiled upon barren ground, immediately grass grew up from it. If she combed her hair, her hair showered forth precious stones; and if she shed tears, her tears turned into drops of silver and gold. But, to take the care that was thought requisite, of so beautiful and excellent a Princess, she was kept in a Palace of stone, forty fathoms high, *and where neither the Sun nor the Moon could be seen.*

I quote the words of the Arabian author only in the words of his English *translator, who, as I think*, has partly misrepresented his meaning. *My young* readers will be surprised at hearing of a palace "where neither the Sun nor the Moon could be seen," only because of its great height; even if that were forty fathoms, or two hundred feet! They know that astronomers are particularly fond of *great heights*, for the express purpose of "seeing" still so much the better the Sun, Moon, and Stars; and that for this very reason, some *high mountains* are often fabulously described as the ancient resort of *astronomical giants* for that purpose: of which we have an example in the Welsh mountain, Cader Idris, or the Chair of Idris; fabled to have had its top used as a seat by the astronomer and giant Idris, while studying the Stars.

But what, no doubt, is really said by the Arabian, is in itself sufficiently marvellous, though more consistent with right reason. He says, that the beautiful but unfortunate Princess Corecli was confined in a palace of which *the walls* about it (being forty fathoms high) hid from her sight the Sun and Moon; that is, she could see neither for a long time, while they were ascending or descending in the skies, as all of us usually do, but only for the short times when, if ever, they were directly over her head! And, here, my ng readers know, that this is a very possible effect of being surrounded, either by high mountains, or by high walls; so that every day, or every night, in deep valleys, both in this country and in others much more mountainous, the Sun, or Moon, or Stars, can only be seen, or even their light received, for a few hours, and never at their rising or their setting. In the course of my travels in the North of Europe, I picked up a pretty little fancy of a poet of the cold country of Lithuania, suggested by these hidings of the sun upon one of the sides of high mountains, as well as by the early and late enjoyment of its presence upon their opposite sides—which follows, as you know, of course: "Why art thou so late, this morning, O Sun?" inquired (says my poet) of the Sun the Day. "I lingered," answered the Sun, "upon the other side of the mountain, to warm two orphans sitting at a cottage door."

But thus, then, this account of the palace of the Princess Corecli reminds us of two valuable considerations, as to a possession of the light of the Sun, and Moon, and Stars. My young readers (if, indeed, any of them are not quite so beautiful as that Princess.

nor so capable of producing buds, and grass, and precious stones, and drops of silver and gold,) are certainly more fortunate in the free view of the all-glorious skies! The youngest child, in the smallest garden, has the means of this indulgence; and I am sure that the sight of the Sun, Moon, and Stars has continually attracted the attention of every one of those whom I am addressing.

Simply, however, to *see* the Sun, Moon, and Stars, is not enough for my young readers. They want to know what they are;—to know where they are;—to know why and how they shine;—what blessings they pour down upon us;—and how they are supported in the heaven and yet made to move! They want to know about Eclipses, the late Comet, and Shooting or Falling Stars, of which last so many extraordinary things are just now said? But instruction and entertainment upon all these subjects are the very aims of my little book, which, without further remark, I therefore commend to their kind welcome.

PETER PARLEY.

ADVERTISEMENT

TO THE

SECOND EDITION.

The pleasant news that I lately had from my Publishers, about the rapid sale of I cannot tell how many thousand copies of the first edition of this little book, and the absolute necessity they were under to print, as quickly as possible, I cannot tell how many thousands more;—all this, as my little readers will believe, flattered me very much; but it also seemed to impose upon me a fresh duty.

"Why, bless me! Gentlemen Publishers," said I, "if it is really true that so many little boys and girls are to learn their first accounts of the Sun, Moon, and Stars, from Old PETER PARLEY, I must take still more pains than before, to make my Tales about all these heavenly bodies as worthy of my scholars as I am able. Though the ice and snow are thick and slippery upon the ground, and though hundreds of sad young rogues are thoughtlessly making slides on the footways, yet I can hobble along, with cautious steps; so, I will not only go home, but I will go to several friends and public places of instruction; and both reconsider all that I have already written in these Tales, and collect all that I can hear of, which ought now to be added to all that was in my first edition. I know, that even in the few months which have elapsed since the printing of those pages, several novelties have presented themselves, in the history of the knowledge of the Sun, Moon, and Stars; and I shall go back, instead of going forward, if I do not bring them into your new impression, however hastily you may desire its appearance: My little followers cannot properly be said to be taught astronomy, unless they are informed of its latest truths, no less than its most ancient."

My Publishers listened to my arguments (beseeching me, however, to lose no time,) and accordingly I have been enabled, through a little patience upon their part, and through the help of a learned friend or two, very greatly to improve as well as multiply my chapters; and to subjoin this brief account of the new points about which I have given notices of less or greater length.

I. Later and fuller accounts of the extraordinary telescopic appearances of Halley's Comet, as seen in the years 1835 and 1836, in Europe, and at the Cape of Good Hope, appear in this edition; with fuller explanations of the astronomical interest attached to the punctual reappearance of that Comet; and with other new facts, relating to the history of Comets in general.

II. The Annular Eclipse of the Sun, of the 15th of May, 1836, as well as the general explanation of Eclipses, are here amply described to the youthful reader.

III. The whole of the little that is yet known of the Fifth New Planet, of which the existence is certified to us by Signor Cacciatore, in Italy, and by M. Valz, at Nismes, is given in this impression.

IV. Reports of Observations of the "November Asteroïds," or Shooting or Falling Stars, as seen in Europe on the night of the 13th of November, 1836, are added to what had been stated in the first edition; together with other facts, and with accounts of the Planetary explanations of Messrs. Arago, Olmsted, and Biot; of the Meteoric explanation, both of these *stars*, and of the *zodiacal light*, by other astronomers and philosophers; and a retrospective glance at the opinions of the preceding century, as to Shooting or Falling Stars, and Star-jelly; and at the improved explanation, in the same century, of that particular substance, *Star-jelly*, as being either vegetable, or else naturally formed of the bodies of *dead frogs*.

V. Sir John Herschel's latest description of his discoveries and observations under the Southern Celestial Hemisphere, will be found in this edition.

VI. The formal denial of the pretended "Lunar Discoveries" of the same indefatigable astronomer, appears, also, in these pages.

VII. In the brief chapter upon the Centrifugal and Centripetal *Forces*, room, though but of two lines, has been found, for intimating the existence of the new doctrine of Professor Mozotti, of Corfu, already favourably received by the highest philosophical authorities in England; a doctrine which, enlarging, but not detracting from the philosophy of Newton, reduces the phenomena of all the *forces* discovered in nature to a *single force;* conformably with the glimpse of many preceding inquirers, and with the persuasion, for years past entertained, that. "perhaps the day may come, when even *gravitation*, no longer regarded as an ultimate principle, may be resolved into a yet more general cause, embracing every law that regulates the material world."*

To admit the introduction of these new materials into the volume, besides an extension of the number of its pages, many chapters, or parts of chapters, have been re-written, or re-modelled, and many changes as to the distribution of the engravings have been made; all to the end of providing, for the little readers of the work, increased instruction, pleasure, and entertainment.

Finally, the *order* of almost the whole of the chapters (and that, therefore, of the several topics to which they are respectively devoted) has been entirely new disposed. In doing this, a notion has been acted upon, that the most *general* contemplation of the heavenly bodies, and a *description* and explanation of their most obvious, and most familiar phenomena, are the objects of the earliest interest to the youthful observer; and that all which is particular, and still more all which is recondite, and the topic of a higher curiosity, should come but after the foregoing. With this view, the *order* observed in the present impression, after commencing in a manner incapable of improvement—that of dilating upon the Moon, and of illustrating the Moon, which is *always* distant from us, by a Balloon, which we can see both near and at a distance;—this *order* leads us, in the second place, to the Sun; then, to the Stars; then, to the Nebules of the astronomers; thus embracing the whole heaven under a *general* aspect; and thus leaving us to contract our subsequent picture from the whole starry heaven, to that of what Sir William Herschel has called the Nebule of the Earth, within which is the Solar System; and, in this System, to descend; at last, from the *general* survey of all its Planets—all its Comets—and all the recent suggestions of its extended contents—to our single and dearest planet the Earth, with its familiar and yet wonderful phenomena of Day and Night, and the Four Seasons. We descend, in short, even in the bounds of the Solar System—

---

* Somerville's Connexion of the Physical Sciences. London. 1836.

> From solitary Mars; from the vast orb
> Of Jupiter, whose huge gigantic bulk
> Dances in ether like the lightest leaf;
> To the dim verge, the suburbs of the System,
> Where cheerless Saturn, 'midst his watery moons,
> Girt with a lucid zone, in gloomy pomp,
> Sits like an exiled monarch;*

---

* Barbauld's Summer Evening's Meditation. London. 1771. The Georgium Sidus was at this date unknown.

and, after having begun our contemplation from the Earth, repose upon earth once more:

——————The known accustomed spot,
Dressed up with sun and shade, and lawns, and streams:—
A mansion fair and spacious for its guest.
And full replete with wonders.*

Upon the whole, then, the second edition of my TALES OF THE SUN, MOON, AND STARS, presents almost an entirely new and original volume, the contents of which (as it is hoped) will be found at least not less pleasing, nor less instructive, than those that were offered in the first impression.

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* Barbauld's Summer Evening's Meditation.

SIR WILLIAM HERSCHEL.

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SIR ISAAC NEWTON.

PETER PARLEY'S TALES ABOUT THE SUN, MOON, AND STARS.

CHAPTER I.

PARLEY TELLS ABOUT A BALLOON.

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1. HERE is a picture of a balloon. It is an immense bag of silk, as big as a small house. A

net is thrown over it. To the bottom of this net is attached a little car, in figure like a boat.

2. The balloon is filled with gas, which is a kind of air. This gas is very light, and as it rises up, it takes the balloon, car and all, up with it. Two of the persons in the car carry each a flag in his left hand.

3. The balloon has just begun to ascend. It is now no higher than the top of a house. A great many people are standing below, looking at the balloon. They can distinctly see the little car, and the aëronauts in it. They can see the little flags, which they are waving in their hands. They can see the network that is over the balloon, and can easily distinguish the countenances of the adventurous persons who are now taking a ride into the regions of the clouds.

4. Well! the balloon rises higher and higher! it is soon far above the tops of the highest steeples. How small it looks! The little flags in the aëronauts' hands are not to be seen. The aëronauts themselves appear like specks, and the car is scarcely visible.

5. Still it continues to pierce further and further into the regions of air; it is borne along by the wind, and passes rapidly away over the hills and valleys, and woods and meadows, and villages and towns.

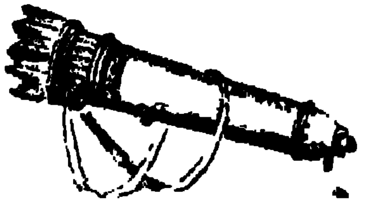
6. Look! here is still another picture of the balloon. How very small it appears to be! It

seems scarcely bigger than a pin's head. It is, you see, higher than the clouds, and I suppose is now about twenty miles off. We can see nothing but a dark speck; yet we know that it is the same balloon; we know that it is very large; we know that it has a car attached to it; and that several men are riding along with it.

7. Now, what is the reason that this balloon appears so very small? Why cannot we see the car and the men? You will tell me it is because they are so far off. Very well! that is what I wish you to remember. Anything a great way off, appears smaller than it really is. A balloon, that is as big as a small house, does not look bigger than a pin's head, when it is twenty miles off.

QUESTIONS

1. Describe a balloon. 2. What carries up a balloon into the air? 6. How large does a balloon appear to be, high in the air, and at the distance of twenty miles? 7. Why does a balloon look so small, at the distance of twenty miles?



CHAP. II.

PARLEY TELLS OF THE MOON. MAP OF THE FULL MOON. POWERS OF TELESCOPES.

1. HERE is a picture of the moon. You have often seen the moon. How very beautiful it is! When the sun is set, how sweetly the moon shines on the trees, and on the grass!

2. Have you never looked up at the moon, and wondered what it was? This is what I am now going to tell you.

3. How large does the moon appear to you to be? I suppose not larger than a melon? But remember it is a great way off. It is many thousands of miles from us. It is, therefore, a great deal larger than it appears to be. It is many thousand times larger than the balloon. It is a great deal larger than all the mountains you ever saw, put all together.

4. The moon is, in short, a planet. It has mountains, and valleys, and plains upon it, but, as some would persuade us, it has no water. We cannot see these mountains and the rest of the objects with the naked eye, because they are so far off.

5. I showed you how small, and how dwindled to an almost imperceptible point, a balloon, the size, and figure, and colours, and the rest of which we know;—how small and dwindled, and indistinct, and finally imperceptible, a balloon may become, through its being raised high

into the air, or carried to a distance from our eyes. Now, you are to consider the reverse of this. You are to think how large, and how distinct the moon would easily seem, could it be but brought nearer to us! For, as the balloon seems to grow smaller and less distinct, the further it departs from us; so, the moon would seem to grow larger, and all that belongs to it more distinct, the nearer it could be brought to us, or the nearer to it we could go.

6. But, though we can have no hope from any change of the real distance between us and the moon, there are admirable instruments (spyglasses and telescopes, of which I shall say more another time) which so effectually afford us views of distant objects, in the same manner as if they were brought nearer, that the difficulty of distance, by their help, is very much overcome. It is for this reason that while the learned denomination, *telescope*, signifies what *shows us distant things*, sailors have found out a plain English name for the same instrument—calling it a *bring-'em-near*.

7. Well, then! by help of a telescope, we get views of the moon that are wonderfully minute; and such are the daily improvements that are now making in telescopes, that it is almost impossible to say with what distinctness we shall come to see objects in the moon. The distance of that planet from the earth is reckoned to be two hundred and forty thousand miles, or thirty times the distance from one end of the world to the other, measured through the centre; but makers of telescopes assure us that, if not now, yet very soon, we shall have instruments to show us the moon as if its distance were only sixty miles; add to which, that if, at the time, our own sky or atmosphere is clear, we ought to have nothing to obstruct our prospect, through clouds or hazy weather in the moon: for the moon, as some also assure us, has no atmosphere at all. Here, then, is a map of the moon, such as it shows itself at its full; and as discovered through a telescope, though yet a far inferior one to the powerful instruments now promised to us, or even to the most powerful of those now made.

QUESTIONS.

3. How large is the moon? 4. What is the moon? What are on its surface? Why cannot we see the mountains in the moon? 5. Does a balloon seem smaller and less distinct the higher it ascends? Would the moon seem larger and more distinct the nearer it should come? 6. Do telescopes give us the same views of the moon as if it really came nearer to us? What do sailors sometimes call a telescope? 7. What is the moon's distance from the earth? Is it said, that we shall become enabled to view the moon as if its distance were no more than sixty miles? Is it said, that there are no clouds or hazy weather in the moon, to interrupt our prospect?

CHAP. III.

PARLEY TELLS AGAIN OF THE MOON. SPOTS UPON THE MOON. FACE OF THE MOON. OLD WOMAN IN THE MOON. MAN IN THE MOON. GERMAN PHILOSOPHER. PERUVIAN TALE OF THE SPOTS ON THE MOON.

1. You may now compare this telescopic map of the moon with what you can yourself discover in it, at its full, with only your little naked eyes. Bright, and white like silver, as the moon is, your commonest view shows you gray or darkish spots or marks upon it; and those spots or marks, which you constantly see upon the moon, are what this map shows you more distinctly, or, at least, more minutely.

2. What the spots or marks, to the mere naked eye, look like, in the moon, is variously described, both by different people, and from different causes. Some think them like eyes, nose, and mouth in a human face; and thus it is, that, besides our talking of the *face* of the moon, meaning only its *surface*, figure, or appearance, it is often painted as a real human face.

Others say, that the same spots or marks are like an old woman, bent almost double; while others, also, tell you that they are like an old man, who is carrying a lantern, or else a reaping-hook, and a bundle of sticks; and is followed by a dog. By the first of these, something, perhaps, is alluded to, concerning Hecate, or the fabled witch or goddess of the moon; and, by the second, concerning the equally fabled Man in the Moon. But of both of these, as they have nothing to do, either with astronomy, or with natural history, or with natural philosophy, I add no more.

3. Much, in the mean time, has been said and written upon the latter subject particularly; and, very lately, a critical writer tells us, that a German philosopher once proposed to scale the heaven for the purpose of ascertaining the fact or falsehood, that there is a Man in the Moon, armed with a reaping-hook; and that he certainly would have prosecuted his design, if he could but have hit upon the means of making the necessary ascent.

4. The Peruvians have a tale, that the spots on the moon have been occasioned by a beast of the forest, which, being in love with the moon, climbed up to it and dirtied it with his paws. This is to be understood, however, as a jest.

QUESTIONS.

1. Are there spots upon the face of the moon? How are those spots explained by the telescope, and upon the map? 2. What about a human face in the moon? What about an old woman? What about an old man? What about a fabulous witch or goddess in the moon? 3. What about a certain German philosopher? What about the man in the moon? 4. How do the Peruvians account for the spots upon the moon?

CHAP. IV.

PARLEY TELLS STILL MORE OF THE MOON. TELESCOPIC APPEARANCES IN THE MOON. ANCIENT ACQUAINTANCE WITH THE MOON. ANCIENT AND MODERN QUESTIONS. CRESCENT, OR INCREASING MOON, EASTWARD OF THE SUN.

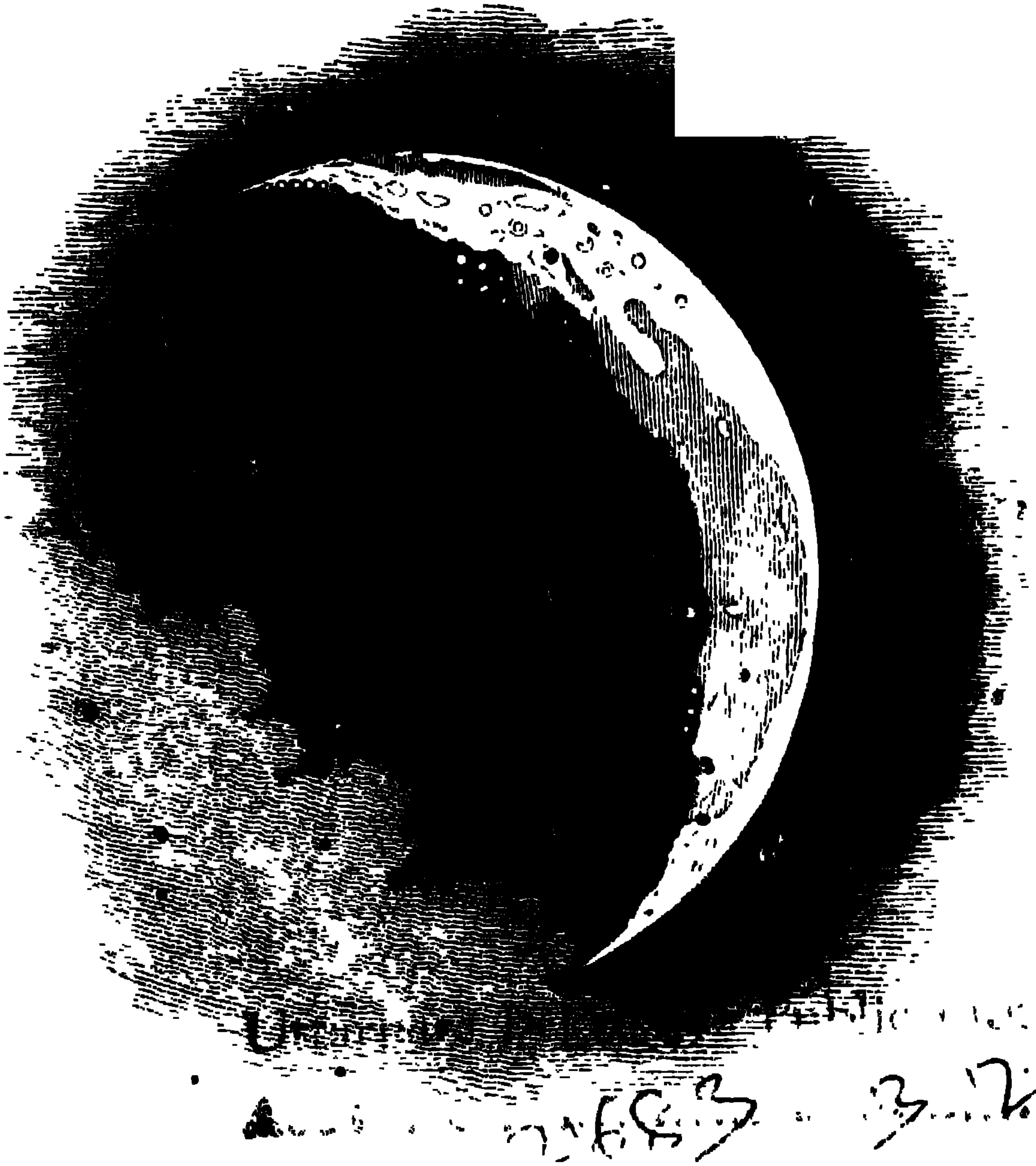
1. The moon has always fixed in a considerable degree the attention of mankind. I must not stop to recount to you in how many ways it has been the object of their thoughts and examina-

tion. In modern times the improvements in the telescope have assisted a wonderfully minute examination of its surface. That surface is held to be full of mountains, and on the tops of most of its mountains are held to be the cups, or craters, or circular hollows, of volcanoes.

2. Galileo is often reputed the inventor of the telescope; and he, at least, in the year 1608, or 1609, constructed one, and published accounts of the discoveries he made with it. But, whenever, and by whomsoever, the telescope was invented, antiquity had not waited for Galileo, in order to form those very notions of the moon which the moderns are proud of entertaining. Among the verses attributed to Orpheus, are some that describe the moon as containing mountains, plains, and even cities; Democritus attributes the spots in the moon to the shadows of its hills and mountains; and even its support and motion in the heavens were philosophically accounted for by Anaxagoras, and by others of the old Grecian schools.

3. I have shown you the figure of a full

moon; where it is; its mountains, which cause it to offer to the telescope that jagged internal outline which appears in this beautiful figure of the planet, when, a little after the new moon, it



is seen as a fine crescent, to the eastward of the sun, a short time before it sets.

41 Whether the moon has *cities*, that is, whether it is inhabited by men, women, and children like ourselves, as well as other points, are matters still debated by many philosophers; but, in my humble opinion, you will always deny that this habitation is in any degree probable. I pass, at present, to quite another subject.

QUESTIONS.

1. Are the spots upon the moon occasioned by the peculiarity of its surface? Is that surface diversified into mountains and valleys? Are the mountains said to contain volcanoes? 2. What did the ancient Greek philosophers say of the moon? 3. What is the evening telescopic figure of the crescent, or growing or increasing moon, a little after the new moon?

CHAP. V.

PARLEY TELLS OF THE MOUNTAINS IN THE MOON. SIR DAVID BREWSTER'S DESCRIPTION OF THE MOUNTAIN-SCENERY IN THE MOON, AND HIS DISAGREEMENT WITH SIR WILLIAM HERSCHEL AS TO THE HEIGHT OF THE MOUNTAINS.

1. Before the time of Sir William Herschel, some of the mountains in the moon were held to be of the most extraordinary height, in proportion to those of the earth; and you may still meet with statements of that kind in many modern books; but "I believe," says Sir William, "that the height of the lunar mountains is in general overrated, and that when we have excepted a few, the generality do not exceed *half a mile* in perpendicular elevation."

2. The following description of the mountain-scenery of the moon, by Sir David Brewster, (if, considering its poetical tone, it can be wholly trusted,) is, in the meantime, sufficiently striking: "The mountain-scenery of the moon bears a stronger resemblance to the towering

sublimity and terrific ruggedness of the Alpine regions, (the Swiss Alps,) than to the tamer inequalities of less elevated countries. Huge masses of rock rise at once from the plains, and raise their peaked summits to an immense height *in the air*, while projecting crags spring from their rugged flanks, and, threatening the valleys below, seem to bid defiance to the laws of gravitation. Around the base of these frightful eminences are strewed numerous loose and unconnected fragments, which time seems to have detached from the apparent mass; and, when we examine the rents and ravines which accompany the overhanging cliffs, we expect every moment that they are to be torn from their base, and that the process of destructive separation, which we had only contemplated in its effects, is about to be exhibited to us in tremendous reality! The mountains called the Apennines, which traverse the moon's disc from north-east to south-west, rise with a precipitous and craggy front from the level of the Mare Imbrum. In some places, their perpendicular elevation is *above four miles;* and, though they often descend to a much lower level, they present an inaccessible barrier to the north-east, while, on the south-west, they sink in gentle declivity to the plains."

3. But Sir John Herschel, the son of the late Sir William, carries us still further, as to the description of the mountains in the moon; and, here, let me caution my little readers, that I am now talking of mountains *in* the moon, which are topics of *astronomy;* and not of the Mountains *of* the Moon, (so called,) which are certain mountains in Africa, and belong, therefore, to *geography.*

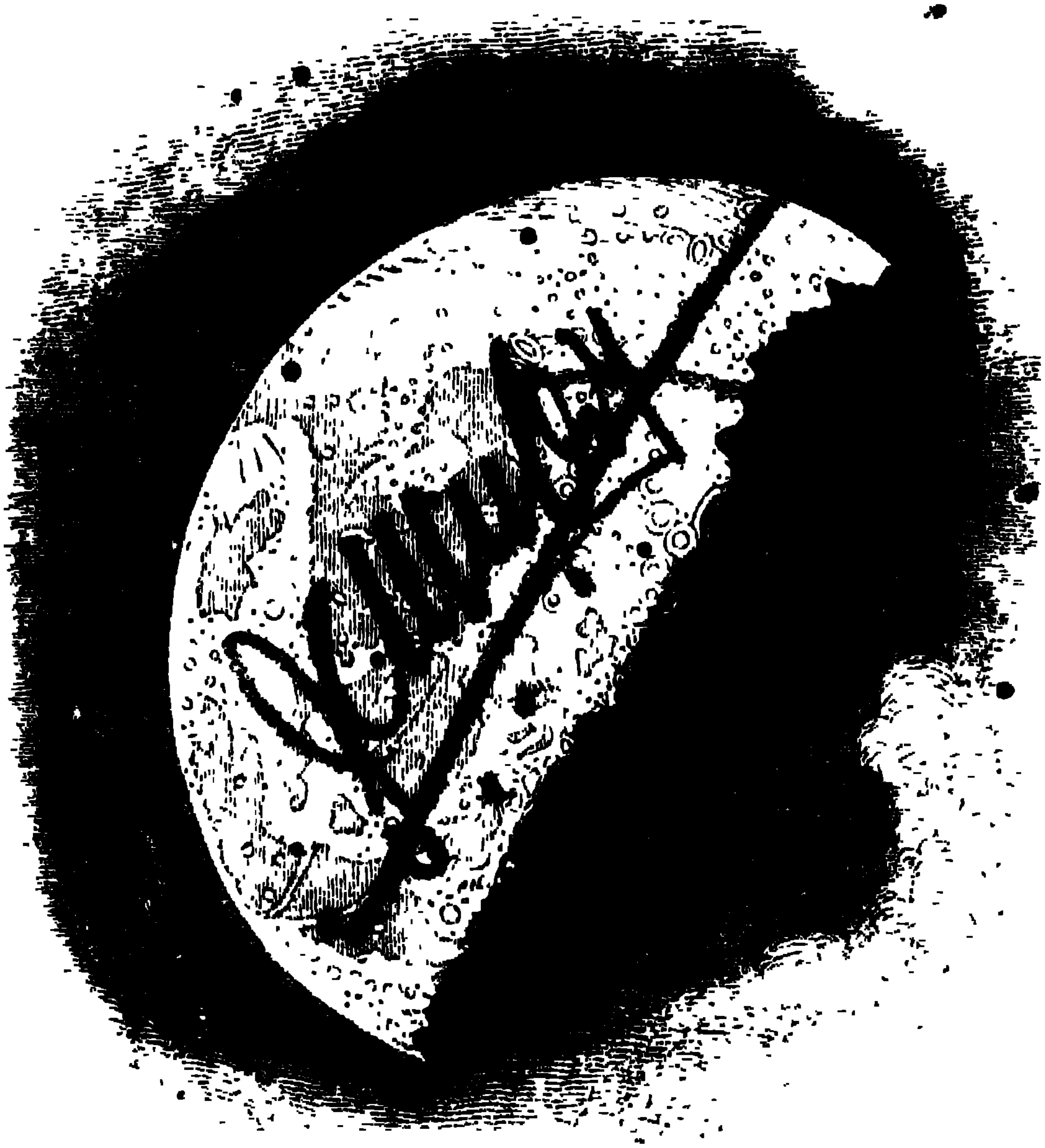
4. After this account of the mountain-scenery in the moon, which (if you have not heard it before) must, no doubt, have greatly surprised you, it will still appear very wonderful that Sir John Herschel, by the help of improved telescopes, is able to talk of the actual *geology* of the moon, or of the stratification and composition of those rocks which Sir David Brewster so minutely and terrifically pictures!

5. "The generality of the mountains in the moon present," says Sir John, "a striking uniformity and singularity of aspect. They are wonderfully numerous, occupying by far the greater part of the surface, and almost universally of an exactly circular or cup-shaped form, foreshortened, however, into ellipses towards the limbs; but the larger have, for the most part, flat bottoms within, from which rises centrically a small, steep, conical hill. They offer, in short, in its highest perfection, the true volcanic character; and, in some of the principal ones, decisive marks of *volcanic stratification*, arising from successive deposits of ejected matter, may be clearly traced with powerful telescopes."

6. The appearance of these "cup-shaped" summits, or *craters*, will be remarked as conspicuous in my figures. The "foreshortening," mentioned above, belongs to the perspective of the circles, which are turned away from the eye, upon the retiring sides of the globe or ball of the moon.

7. The figure upon the next page, besides

showing you some of these craters of the volcanoes in the moon, shows you also the moon



in its decrease, or third quarter; or when only its eastern half is enlightened.

QUESTIONS.

1. What has been said about the height of the mountains in the moon? 2. What description has been given of the mountain scenery in the moon? Does Sir David Brewster seem to support, at least partially, the older opinion, as to the great height of the mountains in the moon? 5. How does Sir John Herschel describe rocks, mountains, and volcanoes in the moon? 6. How does Sir John Herschel's account of the numerous craters in the moon, agree with the circular figures upon Parley's three maps? What are the craters of volcanoes? 7. What is the telescopic figure of the moon in its decrease?

CHAP. VI.

ABOUT THE VOLCANOES IN THE MOON. ABOUT THE LIKENESS OF THE VOLCANOES IN THE MOON TO THOSE UPON OUR OWN GLOBE. ABOUT CLOUDS AND WATER IN THE MOON.

1. THE existence, however, of volcanoes in these mountains in the moon, was not steadily believed till they were described by Sir William Herschel.

2. In 1778, Don Ulloa, observing an eclipse of the sun, saw a small bright spot, like a star, near the edge of the moon; but "supposed it to be a hole or valley, which permitted the sun to shine through it."

3. But astronomers began at length to suspect,

that the lunar appearances of this kind belonged to volcanic eruptions; and in 1787, (ten years after the observation of Don Ulloa,) Sir William Herschel published what follows: "On April 19th, 10h. 6m. I perceived three volcanoes in the dark part of the new moon. Two of them are either extinct, or, otherwise, in a state of going to break out. . . . The third shows an actual eruption of fire or luminous matter: its light is much brighter than the nucleus of the comet which M. Mechin discovered at Paris on the 10th of this month." On the night succeeding the 19th of April, Sir William found his third volcano burning with greater violence; and by measurement, he found that the shining or burning matter must be more than three miles in diameter: it was of an irregular round figure, and very sharply defined about the edges. The two other volcanoes resembled large faint nebules, or brightish clouds or vapours, gradually brighter towards their centres, but without any well-defined luminous spots. "The appearance," adds Sir William, "of what I have called the actual fire or eruption of a volcano, exactly resembled a small piece of burning charcoal, when it is covered by a very thin coat of white ashes, which frequently adhere to it when it has been some time ignited; and it had a degree of brightness about as strong as that with which a coal would be seen to glow in a fair daylight."

4. The same appearances in the moon had actually been observed at the Royal Observatory at Paris six days before their being seen by Sir William Herschel; and described as like a star of the sixth magnitude, but with a brightness occasionally increased by flashes.

5. Other French astronomers saw the same thing; as in the example of M. Villeneuve, on the 22d of May, 1787. The volcano referred to is on the north-east part of the moon, about three degrees from its edge, and toward the spot which astronomers call Helicon.

6. But, here, from the names Apennines, Helicon, and Mare Imbrum, or Imbrum Sea, you will perceive that (as is the fact,) astronomers have distinguished the different figures

on the moon as if by *geographical* names; just as, in a map of the world, we talk of France, England, Mount Caucasus, and other mountains and countries.

7. You will have also perceived, both here and above, that at least our older astronomers supposed the existence of *water* (that is, rivers, seas, &c.) in the moon; and, if a certain opinion which has been hazarded has good foundation, namely, that there are no volcanoes upon our own globe, but where the neighbourhood of the *sea* affords the access of sea-water to the combustible materials of the mountains; and that, where the *sea* has retired, there, ancient volcanoes have ceased to burn; then, our newer philosophers must explain how there happen to be *volcanoes* in the moon, and yet no *water!* We have volcanoes in even the bed of the sea, but none where the sea is not at hand.

8. I confess, in the meantime, that I do not understand this history of the volcanoes of the moon; that is, of volcanoes where there is no water! I can just venture to suppose them (if

so required) without *smoke;* but I cannot suppose them without coloured heat, and yet visible! I cannot, in short, suppose heat, or fire, or the action of combustible materials, without the presence of humidity or water; neither can I understand that there should be, in any part of creation, the presence and activity of one element, or of any compound of elements, without the presence and activity of all elements, and of all the elemental compounds?

9. Happily, too, for the credit of my doctrine, Professor Gruithuisen, of Munich, (an indefatigable explorer of the moon,) has just now come to the belief, that the moon has clouds, and consequently an atmosphere. But, if the moon has clouds, it consequently has *water*. The Professor says, that his telescope has lately shown him those two mountains in the moon, that have been call Eudoxia, and Aristotle, covered with a number of points, which have afterwards changed their position; and these moveable points, he is of opinion, can be nothing else than clouds.

QUESTIONS.

1. When did the existence of volcanoes in the moon begin to be believed? 2. What did Don Ulloa observe in the year 1778? 3. What discovery was made by Sir William Herschel, in the year 1787? 4, 5. Were Sir William's observations concerning the existence of volcanoes in the moon, confirmed by those of other astronomers? 6. Have astronomers given names to regions, mountains, valleys, and other places, upon the moon, as geographers give them upon the earth? 7. Has anything ever been said about seas, rivers, and other waters, actually existing in the moon? Has an opinion ever been expressed, that where there is no sea, there can be no volcano?

CHAP. VII.

PARLEY STILL TELLS ABOUT THE MOON. WHAT THINGS MIGHT BE SUPPOSED TO BE SEEN UPON THE EARTH, IF THERE WERE ASTRONOMERS AND TELESCOPES IN THE MOON.

1. I SHOULD never have done, if I were to tell you only a hundredth part of what is to be said concerning the moon; but there are some particulars still untold, either so new, or so rarely mentioned, or so very entertaining, that I cannot omit to add them.

2. You have been startled by much that you have heard of the close acquaintance of modern astronomers with the moon. The old *astro-*

logers could hardly have pretended to more, though of a very different kind. But the acquaintance of the inhabitants of the moon (supposing that there are such, and that they are as well provided with telescopes as ourselves,) with most things upon the earth, is still closer than ours with the things of the moon, if we can believe M. Quêtelet, a living and highly respectable authority, and a man of science, peculiarly devoted to the study of subjects of exactitude.

3. " Our vast continents, our seas, even our forests," says M. Quêtelet, (Astronomie Elémentaire, Paris, 1826,) " are visible to them: they perceive the enormous piles of ice collected at the Poles, and the girdle of vegetation which extends on both sides of the equator; as well as the clouds which float over our heads, and sometimes hide us from them. The burning of a forest or town could not escape them; and, if they had good optical instruments, they could even see the building of a new town, or the sailing of a fleet!"

4. But some, at least, of these things will appear the less incredible to you, the more you know about the real intimate relations between the earth and moon; and the reported facts which follow, will perhaps assist you in that respect.

5. It frequently happens, about three or four days after the new moon, that within the crescent appears the rest of the figure of the moon. I have represented this appearance in the beautiful figure which forms my Frontispiece; and which I will, here, consider only as showing the ash-coloured light which covers so large a part of the disc, and which is that of which I am now speaking.

6. This phenomenon is what the French call *la lumière cendrée*, that is, "the ash-coloured light;" and it arises from the reflection of the light (that is, of the sunshine) from the earth upon the moon, which thus illuminates, to a certain degree, that face of the moon which is presented to the earth. The thin crescent, at such a time, reflects to us the full blaze of the solar light; and the rest of the surface of the moon reflects to us the light reflected upon it

from the earth;—a light similar to moonlight, except that this *earth-light* goes to the moon from a body thirteen times larger than the moon, while moonlight comes to the earth from a body thirteen times less.

7. It is observed that this *lumière cendrée* is brighter upon the moon when the continents of the earth are opposite, than when either the Atlantic or Pacific Ocean is in that position. The sea reflects less light upon the moon than the dry land; and consequently the latter, in those circumstances, reflects less of the *lumière cendrée* upon the earth.

8. But here, again, you will understand, why the spots, or dark parts of the moon, have sometimes been called its seas and lakes—its brighter parts being taken for dry land. According to others, however, the moon has no water whatever; and its spots are dry vales, and cavities, and basins, and shadows of mountains; but all without the refreshment of a single drop of water. I have questioned this already, and cited at least one astronomer to the contrary.

9. The moon, too, it is equally said, is without

an atmosphere, that is, without *air*, (though Sir David Brewster, as we have seen, lifts his lunar mountains into lunar " air,") and without clouds or vapour. But none of these things are finally agreed upon, even by our living astronomers; and, if we consult their various writings, we shall find that there is still room for inquiring whether the moon has *air*, that is, an *atmosphere;* whether the moon has *water;* and even whether its *light* is really but a light *borrowed* from the sun; that is, a reflection of the light of the sun; and not a light of its *own*, drawn forth by the *action of the mass of the sun?* As to clouds, which are vapour, and which directly imply the presence of water, I have told you that M. Gruithuisen believes himself to have discovered them on the mountains in the moon.

QUESTIONS.

3. What does M. Quetelet think of the sights which might be seen upon the earth from the moon, supposing that there were in the moon people like ourselves, and telescopes like ours? 6. Do the French astronomers, after the ancients, apply to a certain appearance of the moon the name of *la lumière, cendrée,* or " ash-coloured light:" in Latin, *lumen incinerosum?*

CHAP. VIII.

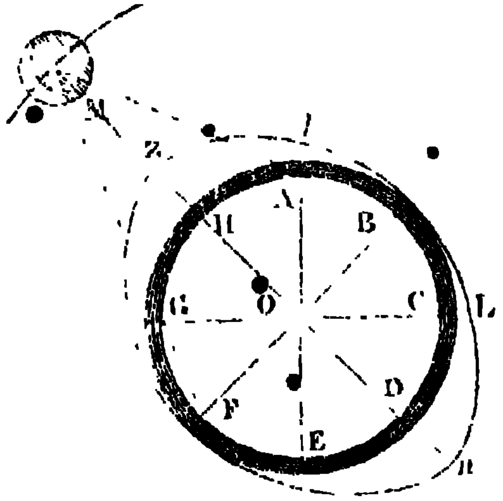
ABOUT THE INFLUENCES OF THE MOON UPON THE EARTH, AND OF THE EARTH UPON THE MOON. ABOUT THE INFLUENCE OF THE MASS OF THE MOON. ABOUT TIDES.

1. ALL the bodies composing the universe exercise influences over each other. The earth influences the moon; the moon influences the earth.

2. The moon is a body, and it is a luminous body; and it appears to exercise influences both as a body and as a light.

3. As a body, that is, as a mass, it exercises the influence of attraction or gravitation; and of this influence of the moon's attraction, a conspicuous effect is generally thought to be the production of the tides of the ocean, from which proceed the tides of the rivers of which the mouths are open to the ocean. There are other opinions of the cause of the tides; but this is what is taught by Newton, and is in the following manner explained.

4. In the diagram which I here show you, M represents the moon, O the earth, *z n*, the highest



parts of the water caused by the moon's attraction. Now let it be observed, that the power of gravity diminishes as the square of the distance increases; and therefore the waters at Z, on the side of the earth A B C D E F G H A, next the moon M, are more attracted than the central parts of the earth O by the moon, and the central parts are more attracted by her than the waters on the opposite side of the earth at *n*; and therefore the distance between the earth's centre and the waters on its surface, under the opposite side to the moon, will be increased.

For let there be three bodies at H, O, and D: if they are all equally attracted by the body M, they will all move equally fast towards it, their mutual distances from each other continuing the same. If the attraction of *n* is unequal, then that body which is most strongly attracted will move fastest, and this will increase its distance from the other body. Therefore, by the law of gravitation, M will attract H more strongly than it does O, by which the distance between H and O will be increased; and a spectator at O will perceive H rising higher towards Z. In like manner, O being more strongly attracted than D, it will move farther towards M than D does; consequently, the distance between O and D will be increased; and a spectator at O, not perceiving his own motion, will see D receding from him towards *n*; all effects and appearances being the same, whether D recedes from O, or O from D.

5. According to later philosophers, however, the tides are produced by the combined influences of the moon and the sun; and even

still present an astronomical problem, the most difficult of solution, and hitherto the least satisfactorily disposed of.

6. Great exertions are at present in the progress of being made, to obtain, by means of continual observation in a variety of places throughout the world, and by the most careful registration of facts, a more complete account of the tides, tending to the discovery of all their causes, than any that is yet possessed.

7. Laplace is a defender of the theory of Newton.

CHAP. IX.

ABOUT THE INFLUENCES OF THE LIGHT OF THE MOON. ABOUT THE WEATHER. ABOUT THE CHANGES OF THE MOON. ABOUT OLD MOONS AND YOUNG MOONS. ABOUT NEW MOONS, FULL MOONS, HALF MOONS, AND THREE-QUARTER MOONS. THE SAILOR'S VOYAGE TO THE END OF THE WORLD, AND HIS DISCOVERY OF THE HEAPS OF THE OLD MOONS.

1. IF the question of the influence of the moon in respect to the tides is still open to examina-

tion, much more so is that of the influence of the moon upon the weather.

2. The ancient and general persuasion is, that changes of the weather follow changes of the moon.

3. The proof must depend upon accurate observation; but there are difficulties even in the way of the theory, if we strictly consider the real history and nature of the moon.

4. I shall leave it to my little readers to form a better judgment of the whole matter hereafter, when they have grown older, and learned a great deal with which they are unacquainted at present, and which even my little book, instructive as well as entertaining as it is, by no means pretends to teach them. There are one or two points, however, which, even now, they may easily comprehend, and which it may be very useful to tell them about here.

5. What are the changes of the moon? There is a story of a sailor, who, having said that he had sailed to the end of the world, and having been asked what there was at the end of the

world, answered, in the first place, "A high wall." But, being further asked, whether he had not had the curiosity to climb the wall, high as it was, and see what was upon the other side of the wall, or *beyond* the end of the world, then replied, that he had done so, and that what he saw was a heap of *old moons!*

6. Now the sailor had drawn upon his fancy, in order to satisfy his inquirers, and also not to be thought deficient either in curiosity or enterprise; and therefore talked as if he believed that the old or worn-out or cast-off moons, being the rubbish or the lumber of the heavens, were finally thrown over the wall at the end of the world, like a gardener's rubbish, and dead roots of flowers, outside the wall at the end of his garden!

7. But what is the opinion of my little readers themselves, about these same *old moons?* When they hear about the old moons and young moons, and new moons, full moons, half moons, and three-quarter moons, do they believe, as they ought to believe, that all these moons are

one moon; and that this one moon is the only moon which mankind have ever had to gaze at, or to be lighted by, since the very earth upon which they tread was itself young and new?

8. And, besides believing that there is not, nor ever has been, more than a single moon, do they believe rightly concerning the real *unchangeableness* of this single moon? Do they know and believe, that the moon (even unlike the sun and all the planets, of which, from time to time, we see each part of the whole circumferences,) is so very uniform, so truly most unchangeable, that it never turns to the earth but one of all its sides?

9. There is, then, but a single moon, and of that single moon there is never any *change.* When my little readers see in the sky, sometimes a thin bow-like moon, sometimes an oval moon, and sometimes a round full moon; when they hear of young moons and old moons, of whole moons, half moons, three-quarter moons; of growing moons, and of waning or decreasing moons; and when they see such pictures of the

moon as those at my pages, 15 and 21, I am fearful that they may think even the one moon sometimes larger and sometimes smaller; that there is more of it at one time, and less of it at another; that it is actually smaller when young and new, like my little readers themselves; and that it grows larger as it grows older, as is to be their own case too!

10. But my Frontispiece, among its other uses, will greatly help to undeceive my little readers in this respect. It shows them that the crescent, or young or growing moon, at my page 15, and the decreasing or waning moon, at my page 21, (though, because they are all that, for the time, is *light* of the moon,) are but the lighted or illuminated parts of a whole moon, of which, for the time, all the remaining part is dark, and only invisible because it is dark; and which is always a whole moon, and is always a moon of one unchangeable size, magnitude, or volume; of one density, or closeness of matter; and of one mass; or one quantity of matter; besides (what they will learn else-

where) that even this one unchangeable moon always turns to the earth one unchangeable side; so that the moon is not even variable with respect to the earth, as the earth is variable with respect to the moon, turning to it sometimes one of its continents, and sometimes one of its oceans!

11. The moon, therefore, has no real changes. But what is it, then, that we mean by the phrase, *changes of the moon?* We mean, changes of the phases or appearances which the moon periodically puts on!

12. And what, then, are these changes of phases or appearances of the moon? Nothing but the changes of the quantity and places of the light which that side of the moon which alone we ever see, periodically is able to display to us! The cause of these changes of places and quantity of the light of the moon, upon the only side that is ever turned to us, (for the quantity of light upon the whole surface of the moon is daily equal,) I shall hereafter tell you; but it may be well to show you, even now, a

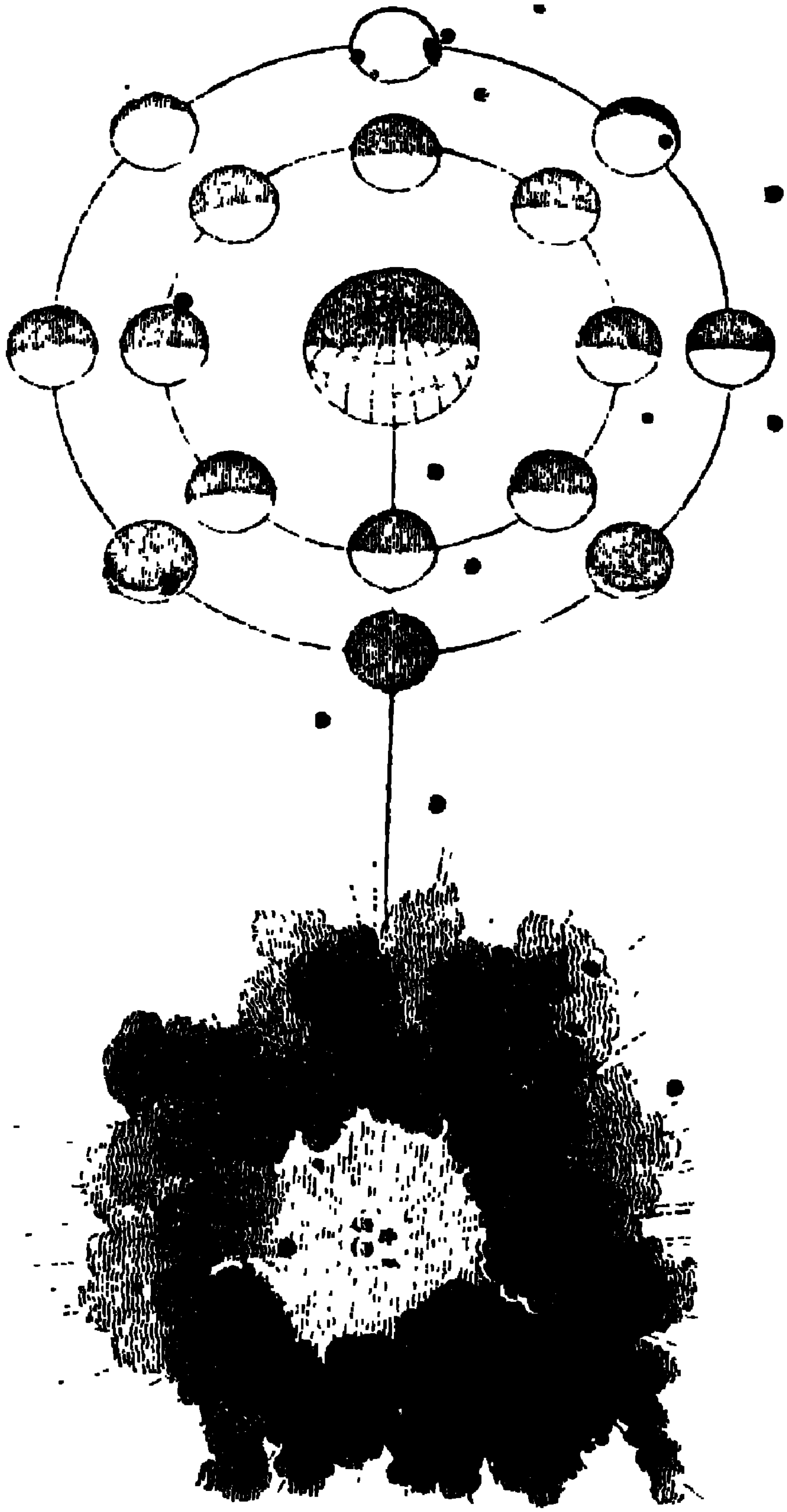


figure of the sun shining upon the moon, while the moon is revolving round the earth; and, in looking at which, you will take care to remember, that all the moons that are there drawn represent but the one moon in the different parts of its orbit round the earth, accompanying the earth in the earth's orbit round the sun.

13. There is no change, therefore, of the moon, except as to the change of the amount of illuminated surface which, from time to time, the moon is able to show to the earth. There is no change of the moon, except a change of the moon's light. There is no change as to the *mass* of the moon; it is to the attraction of the *mass of the moon* that we attribute the phenomenon of the tides; but what is there left, except the changes of the *light of the moon*, to which to attribute the moon's production of the changes of the weather?

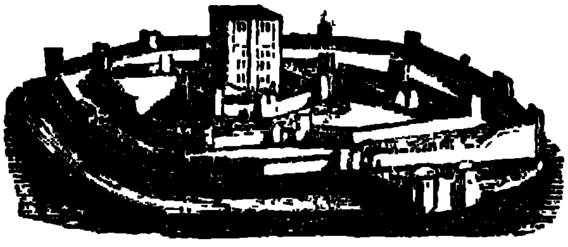
14. The mass of the moon is always equal, and the motion of the moon is constant. The moon passes daily and regularly through all the meridians of the heavens, or over the longitudes

of all the portions of the earth; and the action of the *tides*, or the changes in the heights of the ocean in all its different parts, are regular and daily also. There is consistency, therefore, at the least, in supposing a connexion between the regular daily changes of place of the moon, and the regular daily changes of the heights of the parts of the ocean, or the rise and fall of the *tides;* but what is there reasonably to connect the changes of only *the light of the moon,* with the changes of the wind and weather?

15. The action, both of the *mass of the moon* and of *the light of the moon,* is equal over all parts of the earth; but the winds and weather are regular upon some parts of the earth, and irregular upon others. Can the equal action of the mass and of light of the moon in all parts, be the equal cause of the regularity in one place, and of the irregularity in another?

16. I have said more to my little readers, about the complicated question of the influence of the moon upon the changes of the weather, than I should have permitted myself, if it had

not seemed to me that the points which I have thus brought forward will greatly help them in their reflections upon the nature and history of the moon, and consequently in their knowledge of both. But I have some things still to add, about *the light of the moon,* which I reserve for my next chapter. The light of the moon, (the sole subject of change in the moon,) is certainly a powerful agent in nature, or has powerful influences upon the earth and most things that belong to it; but is it only to changes of *the light of the moon,* that changes of wind and weather are usually ascribed; and can these changes of *the light of the moon,* (regular all over the earth;) be the causes of the changes of wind and weather, regular upon some parts of the earth, and irregular upon others?



CHAP. X.

MORE ABOUT MOONLIGHT AND ITS INFLUENCES. ABOUT THE FREEZING INFLUENCE OF MOONLIGHT. ABOUT THE NATURE OF FROST, OR PHENOMENON OF FREEZING. ABOUT CRYSTALIZATION. M. BECQUEREL AND MR. CROSSE. ABOUT PLAYING AND DANCING BY MOONLIGHT.

1. I HAVE said, that even *the light of the moon* is confessedly a powerful agent in nature; or that, in other words, it has powerful influences upon the earth, and upon most of the things belonging to the earth. I am not going to talk much upon that large subject; but only to mention a striking and beneficent example.

2. Would you believe that light is able to freeze, as well as to warm, the objects which it falls upon? Yet this is said to be the operation, in certain circumstances, of the light of the moon! You must hear me patiently.

3. Very odd things, indeed, are said, and have always been said, of the light of the moon; and in truth, it is right I should tell you, that

all things bad and disagreeable have been ascribed to it, as well as all things agreeable, beneficent, and good.

4. But its freezing, with respect to things proper to be frozen, is esteemed a good. The frosts in the early spring, of which, as to many of their effects, we often complain, are really of great value to the growth of plants. For the moonlight nights in spring cause water to freeze before it is cold enough to freeze in the dark; and thus we have the benefit of frost without exposure to great cold!

5. The buds and leaves of plants, if exposed, on a clear night, to the full moon, are found to be frozen, though the thermometer remains many degrees above the freezing point!

6. I must here, however, add a word or two upon what I have said of the coldness, or comparative absence of heat, in the light of the moon, with reference to its established crystalizing or freezing power.

7. The act of freezing is the act of forming *crystals* of the matter of fluids. But, according

to M. Becquerel, who succeeded in the electrical formation of many crystals, *light* is one of the elements required for crystalization.

8. Cold is only the absence of heat. Fluids, then, being *cold* through the absence of the sun, is it the *light* without *heat* of the moon, which causes them to freeze?

9. But Mr. Crosse, who, with others, has followed the track of M. Becquerel, (and who, with so much modesty, has made such extraordinary advances in modern science,) declares light to be *unfavourable* to the production of crystals; and thus, if he is right upon that subject, he overturns my attempt to refer the freezing influence of moonlight to that *light* unaccompanied by *heat*.

10. What has been called the coldness of the light of the moon, must be only this: that the moon shines in the absence of the sun, and that its light (that is, comparatively speaking,) is without heat.

11. I shall tell you more of this freezing or crystalizing power of the light of the moon;

but now let me close this chapter by calling to all our recollections the merry play of "boys

and girls" by moonlight, when, as the song says,

"The moon does shine as bright as day;"

and yet recommending you not entirely to forget those ill stories of moonlight to which I have alluded; and which make it probable, that such as very much indulge in the beauty and cheerfulness of that light abroad, should, at the same time, be hearty, and be taking exercise.

CHAP. XI.

TELESCOPIC DISCOVERIES IN THE MOON. SIR JOHN HERSC MISREPRESENTED. IMPERFECTIONS OF TELESCOPES INCREASING WITH THEIR POWERS. THE MONSTER IN THE HEAVENS. THE STORY OF THE POOR HOUSE-FLY.

1. I HAVE given you some account of the geographical, and even geological, discoveries which Sir John Herschel, believes himself to have made by means of his telescope, in the moon. I have also told you of the mountain-scenery described by Sir David Brewster, upon the surface of that satellite of the earth.

2. Whether Sir John Herschel has been in any degree too hasty in persuading himself of the reality of what he believes himself to see, is more than your friend Parley can presume to say: but some of his statements have been attacked in France; and ridiculed, in the form of mock productions from his pen, in the United States of North America. In the latter country, a well written pamphlet, entitled a "Supplement to the Edinburgh Journal of

Science," was filled with a pretended account of lunar discoveries by Sir John; and the jest has led to a graver imposition, in which, as the copy of a New York advertisement will show, a panoramic painting is offered to view, displaying the moon as pretended to be seen by our English astronomer:—

"GRAND MOVING PANORAMA OF THE MOON, painted on upwards of one thousand feet of canvass; being a brilliant illustration of the scientific observations made by the most eminent astronomers, of the surface of the moon; showing its various mountains, volcanoes, lakes, rivers, &c.; to which will be added, the reported lunar observations of Sir John Herschel, in which will be seen the *inhabitants*, *animals*, *birds*, *forests*, &c., with their natural motions, to describe life."

3. Upon this subject, Sir John Herschel, writing from the Cape of Good Hope to M. Arago, talks of "the history of his *pretended* discoveries in the moon;" and professes to be amused, that "there are people silly enough to believe every extravagant tale which is set before them." You must be cautious, therefore, how you listen to any of these "*pretended* discoveries."

4. I may tell you, too, in this place, that all the supposed astronomical discoveries, made or to be made with the very powerful modern telescopes, will require strict examination. A difficulty, not yet surmounted, in making lenses for telescopes, is this, that neither care nor skill are sufficient to prevent the occurrence of minute imperfections in the glass; and that these minute imperfections, the greater the power of the instrument constructed, are themselves the more highly magnified, and made capable of deceiving the astronomer, as to what he really sees in the heaven. You know the story of an observer of a late eclipse of the sun, who was thrown into consternation, at the sight, through his telescope, of what he thought an enormous monster in the air; but that turned out to be only a poor house-fly, which had contrived to get into the tube, and had become confined between the two object-glasses!

CHAP. XII.

PARLEY TELLS ABOUT THE SUN.

1. THE sun is one of the millions of stars which have their places in the glorious sky. The sun is a star, and all the stars are suns. It is thus that says the poet,

> "One *sun* by day, by night ten thousand shine!"

2. The sun is a very small star; but, because it is the star which is immeasurably the nearest star to the earth, therefore it appears, from the earth, immeasurably the largest of the stars.

3. It looks larger than the moon, and it is beyond imagination larger. It is prodigiously further off than the moon, but much less so than any of the fixed stars.

4. The sun is the source of light and heat to all the planets of its system. I shall tell of its system presently. If the sun were taken away, the earth would have no light but the dim twinkling of the stars. It would have no day, but only a perpetual night. It would have no

spring nor summer. There would be always winter. The rivers and springs would be frozen up. The grass would grow no more. The trees would die, and all the fruits of the earth would perish. All the earth would be covered with snow and ice, and men and animals would die from cold and hunger. There would be desolation everywhere around, and nothing but a universe in which no plant could flourish, nor anything have life.

5. What would happen to the earth, would happen also to the moon. The moon would receive no light, either from the sun or from the earth. The earth, therefore, would receive no light from the moon, any more than from the sun. There would be no moonlight nights; no changes of the phases of the moon.

6. Such, even as to light and heat alone, would be the awful consequences of the event, if the sun were taken from its place. How beautifully does it seem to come up from the east in the morning! How joyous are the birds at its return, after it has been absent during the night! How fresh and blooming, too, are

the flowers in the spring, when the sun has thawed the snows, or removed the cold of winter! How green are the fields! How soft and balmy is the air!

7. The sun is to us the most astonishing of all heavenly bodies. It is an immense globe, much larger than the planets all together. It is eight hundred and eighty-three thousand, two hundred and seventeen miles in diameter; and about two millions seven hundred thousand miles in circumference. It is one million three hundred and eighty thousand times as large as the earth, or nearly a million and a half. This immense globe is the centre of its system; that is, it is in the middle (or nearly in the middle) of the orbits of its planets. It gives light and heat to all.

8. The sun is no doubt a solid globe, and has probably an uneven surface, like the moon. It is covered with a very bright substance, which gives it its shining appearance.

9. Sometimes this bright substance appears to open, and with a telescope you seem to see through the openings, to the dark body of the

sun. These openings form what are called the spots on the sun. Sometimes these spots can be seen by the naked eye, but generally they are only visible through a telescope.

10. It would take me a great while to tell you of all the benefits we derive from the sun. The truth is, all our comforts, almost all our pleasures, and even our whole existence, depend upon that glorious luminary. Such are the numerous blessings it bestows upon us, that some nations have worshipped it, as the source of every good. Let us, rather, look up with thankful praise to that Almighty Being who *created the sun*, and who commanded it to shed its benefits upon the world that he had made.

QUESTIONS.

4. Where do the light and heat come from? What would be the effect in our world of taking away the sun? 7. What is the most astonishing of all the heavenly bodies? What is the diameter of the sun? Its circumference? How much larger is it than the earth? Where is the sun placed? What does it give to the planets? 8. What gives the sun its shining appearance? 9. How are spots on the sun caused? 10. What are some of the benefits we derive from the sun? Why have some nations worshipped the sun? What ought men rather to worship?

CHAP. XIII.

PARLEY EXPLAINS THAT THE SUN IS NEITHER A DISC NOR GLOBE OF FIRE, AND THAT IT IS IN NO DANGER OF BURNING ITSELF OUT.

1. On the tops of the Himalaya mountains, which rise in the north of India, and reach a height of twenty-seven thousand feet above the level of the sea, the air is extremely rarefied, or thin, and the light of tho sun, by experiment with the thermometer, is found to be accompanied with no discoverable heat. These summits, in short, which therefore supply a name to the mountains, are a region of perpetual snow.

2. In every other case, also, of great elevation above the sea, or above the lower levels of the land, (as of the Andes in America, the Cong mountains in Africa, and the Alps in Switzerland, and of innumerable lower eminences,) the higher we ascend, the colder we find the temperature; and, at certain heights, perpetual ice and snow.

3. Ascents into the higher regions of the atmosphere, by means of those balloons, in drawing your attention to which I began my present volume, discover the same truth; that is, that the higher we ascend, or the further we leave below us that denser atmosphere, which immediately adjoins the sea and the lower levels of the land, the colder we find the temperature, and the less discoverable heat accompanying the sun's light.

4. But, as opposite facts, in the Arctic regions, and in other situations of which the atmosphere is still comparatively dense or thick, while we stand upon beds of ice that are neither melting or likely to melt, except upon the surface, we are often scorched by the heat that we find accompanying the light of the summer's sun. The heat, therefore, is in the atmosphere of the earth, and not in anything which flows to us from the sun.

5. And yet, my little readers, we are all apt to fancy, and the world has ever been apt to fancy, that the heat which we feel in the pre-

sence of the sun's light, (though we often feel heat also in its absence,) must needs come to us from the sun, in company with its light; or, in short, that the light of the sun is the light of a fire; that the sun is a fire—a disc or a globe of fire; and further, that the sun being a fire, it is a fire which must one day burn itself out;—that its heat must diminish or decay;—that it is a burning substance, which must at last burn itself out!

6. But it will be plain to you, that, were there anything like truth in these representations, the very reverse of what I have been mentioning must happen. You know that the nearer you approach to a fire, the hotter you find your place; whereas, I have assured you experience shows, that the nearer we approach to the sun, (that is, the further we go from the centre of the earth, even with the sun over our heads,) the colder is our situation!

7. That the sun gives light; that it is a luminous or shining body; and that, in some manner, its action upon our atmosphere (an action

effective in proportion to the density of the atmosphere) produces the atmospherical heat of which we know so well the experience; these things are certain. But the sun, though luminous, is not fiery; though shining, it is not fire. The sun is no burning disc, nor burning globe; it is in no danger of burning itself out; and it has no heat, nor any material of heat, respecting which there is the least danger that it will either fail or lessen.

8. In truth, it is at present supposed by some, that the light and heat of the sun are to be ascribed only to electrical causes. You must hereafter make yourself acquainted with what is *electricity*.

QUESTIONS.

1. Do we find the air the colder, even in the midst of the brightest sunshine, the higher we ascend from the level of the sea, or of the plains; though, in so doing, we ascend by so much the nearer to the sun? 2. Are the tops of very high mountains covered with perpetual snow? 4. In some situations, do we feel excessive heat under the sun, even while we are standing upon ice which nevertheless continues unmelted? 5. Has it been fancied that the fire of the sun is likely to burn itself out? 6. What contrast may be observed between the

effect of drawing nearer to a fire, and that of drawing nearer to the sun? 7. Is the sun, nevertheless, the certain though hidden cause of the light and heat which we enjoy? Is it plain, that, to whatever changes the sun may really be liable, there is no reason to suppose that either its light or heat are liable to progressive extinction or decay? 8. Do some ascribe the light and heat of the sun only to electrical causes?

CHAP. XIV.

PARLEY TALKS OF THE LIGHT OF THE SUN, AND OF THE SUN'S SPOTS.

1. The intensity of that light which covers the face of the sun, and which the sun diffuses through our atmosphere, may be partly judged of by comparing it, in both instances, with the amount and the influence of the light of the moon. We can look at the moon, but we cannot look at the sun; and the light of the moon, though brilliant, yet leaves the atmosphere so dark that it interrupts our view, neither of the light of the stars, nor of the deep colour of the surrounding sky. In general, while the sun shines, the sky appears to us but of a light azure, and we see nothing of any heavenly body but

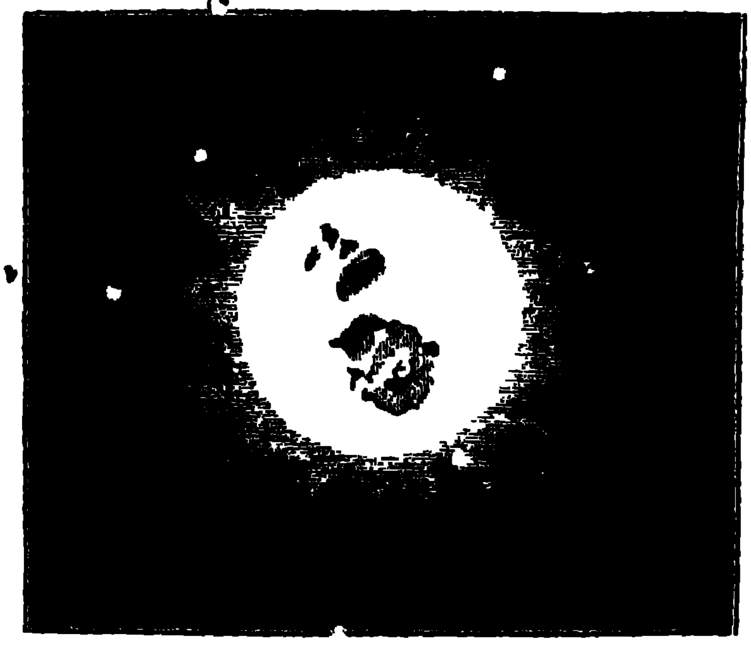
itself; though sometimes the moon, and sometimes one or other of the planets, form an exception to the rule.

2. The cause, in the meantime, of the sun's luminosity, remains unconjectured, or not so conjectured as to satisfy our minds. It is not fire, but what then is it else? Is the sun luminous throughout; or, has it luminous clouds, or a luminous atmosphere only, with a dark and solid body beneath?

3. Sir William Herschel was of opinion, that the sun consists of a dark opaque body or nucleus, in the atmosphere of which float luminous clouds that compose its shining matter. The inferior brightness, and, at the same time, the uniformity of colour of these *shallows*, he explained by supposing that these clouds consist uniformly of two strata, of which the uppermost or outermost is almost immeasurably the brightest; while the lower, or inner stratum, or that nearest to the dark body of the sun, is of very inferior lustre.

4. Leaving, however, these things as unset-

tled as I find them, I shall only tell or remind my little readers, that the sun is not even that uniform ball or disc of light or fire which it seems to their eyes; but that, in spite of all its dazzling golden lustre, it has spots and variations of light and figure upon its face, like the face of the moon; though none of them of that permanent character which enables us to draw a map of the sun in the same manner that we draw, and that I have exhibited to you, in a former chapter, a map of the moon.



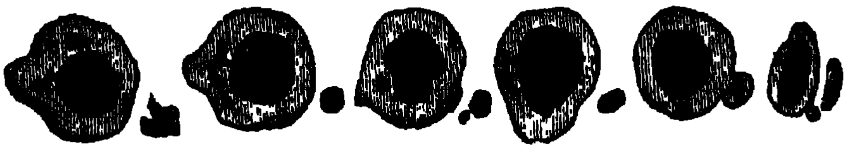
5. Still, I venture to show you, now, a figure

of the disc of the sun, darkened with large spots; but, in the disc of the sun, the number, and the figure, and the size, and the place of all th spots, are in constant variation. They are sometimes so large as to be seen with the naked eye. Herschel, in the year 1779, observed one which was about fifty thousand miles in diameter; or more than six times the diameter of the earth.

6. The changes of place, size, and figure, appear to depend, in part at least, upon the rotation of the sun. For they are thought not to move round the sun, but with the sun. If, then, the spots were permanent, the same spots ought to return at regular intervals, and we ought to be able to draw maps of the two hemispheres of the sun, like those we draw of the two hemispheres of the earth.

7. The spots, if observed for two or three days in succession, seem to have moved, during that time, from east to west, across the body of the sun; but this (the spots being supposed to be fixed) is because the sun has been revolving upon its axis from west to east.

8. When a spot begins to be seen upon the eastern limb or side of the sun, it appears like a thin black line. As it advances towards the centre of the sun, its breadth gradually increases. As it approaches the western limb, it returns to its former figure of a thin black line. This is what you see in these several figures of the same spot, as observed by Hevelius upon several successive days. The seven spots, or double spots, which you may count, show the narrow figure of the spot at its first appearance, and its progressive increase of breadth, as it approached the centre of the disc of the sun.



9. But the same changes of appearance would happen if you were to fasten a black patch upon the side of a globe, and then turn the globe on its axis; so that, if the spot has a fixed place upon the sun, the sun, turning upon its axis, must be the real cause of these changes

of appearance. These changes and motions of the sun's spots prove, therefore, what we could not otherwise certainly know, that the sun, as I have before told you, revolves upon it's axis.

10. The period of the sun's rotation, or revolution upon its axis, and of the consequent revolution of the spots, is different according as the spots are viewed from the several planets above and below the sun. From the Earth, it is twenty-five days, nine hours, and fifty-six minutes; but, as seen from the superior planets, or Mars, Jupiter, &c., the time is shorter; and as seen from the inferior planets, it is longer. From Mercury, the number of days is thirty-five; or, almost ten days longer than from the Earth.

11. But the spots, though subsisting for a time, are by no means permanent; and when they disappear, their places, unless, as often occurs, they are succeeded, in those very places, by spots of peculiar brightness, return to the ordinary appearance of the sun's surface.

12. Once, while Dr. Long was examining the sun's image, as received upon a sheet of white

paper, he observed a large round spot divide itself into two, and each part fly off from the other with immense velocity.

13. Dr. Wollaston, looking at the sun through a twelve-inch reflector, witnessed a similar phenomenon. A spot, which he was expressly observing, burst into pieces, like a piece of ice; and the pieces slid away from each other in various directions, as sometimes happens when we throw a piece of ice upon the surface of a frozen pond!

14. I have given you to understand, that besides dark spots, there also appear, from time to time, upon the face of the sun, spots of peculiar brightness. You have often heard the saying, that there are "spots in the sun," meaning that the most perfect things have blemishes; and therefore the idea of the sun's *dark* spots cannot be quite new to you. But perhaps you did not know till now, that the sun, intensely bright as its whole surface appears to us, has sometimes spots yet more intensely bright! The dark spots were formerly called

maculæ, and the bright spots *faculæ;* but Sir William Herschel, who, between the years 1779 and 1794 inclusive, added so much to our knowledge of the sun's spots and other superficial appearances, changed likewise all the names. For these, as well as for the long list of descriptions and opinions concerning these things, you must hereafter look into the writings of astronomers.

15. The spots have been matter of constant observation, ever since the time of Galileo and the improvements of the telescope. But from the year 1676, to the year 1684, there was not a single spot on the sun.

QUESTIONS.

1. Is the light of the sun prodigiously superior to that of the moon? 2. Has it been satisfactorily explained of what nature is the sun, so that it is luminous, or gives light? 3. What is Sir William Herschel's opinion of the composition of the sun, and the source of its luminosity? 4. Is the face of the sun often obscured by dark spots of considerable size? Why cannot we show those spots in a map of the sun, as, in a map of the moon, we show the spots of the moon? 5. What was the size of a spot in the sun, observed by Herschel in the year 1779? 7. In what direction are the spots of the sun observed to move?

8. Does a spot, while it remains, continually change its apparent figure as well as place? Was this remark exemplified in a spot observed by Hevelius, and what is the reason of the change? 9. What is proved by the apparent changes and motions of the sun's spots? 10. Are the apparent periods of the rotation of the sun and its spots the same, whether viewed from one planet, or from another? Is it different as to the superior and inferior planets? What is the period as seen from the earth? What, as seen from Mercury? 11. Are the dark spots permanent? Do very bright spots often succeed to them? Are both dark and bright spots finally succeeded by the ordinary appearance of the sun's surface? 12. What was seen by Dr. Long, concerning a dark spot? 13. What by Dr. Wollaston? 14. What name was formerly given to the dark spots? What to the bright spots? Who has particularly observed both, and given to these, and to other temporary appearances upon the face of the sun, new names? 15. How long have the spots been made matter of observation? At what time, and for how many years together, was there not a single spot to be seen upon the face of the sun?

CHAP. XV.

ABOUT OPENINGS, SHALLOWS, INDENTATIONS, AND PORES; AND ABOUT OTHER TEMPORARY APPEARANCES UPON THE SURFACE OF THE SUN.

1. THOUGH I have referred you, for many of the appearances observed by Sir William Herschel upon the face of the sun, and for the names by which he distinguished them, to your future reading of larger astronomical books, yet some

of them are so extraordinary, and so likely, in their description, to stimulate your curiosity, that I shall mention a few, under their names of Openings, Shallows, Indentations, and Pores.

2. Openings are appearances under which the dark and opaque body of the sun becomes visible, caused by a removal of the luminous clouds which commonly surround the whole.

3. One of these openings, with a *shallow* about it, and seen on the 4th of January, 1801, a good way past the sun's centre, is represented in Fig. 1. The *opening* is the smaller and darker spot, and the *shallow* is the larger and lighter part of the figure. On the western side of the shallow, its thickness was visible, all the way from its surface downwards; but on the eastern side only the edge of the shallow was visible, so that its thickness could not be seen.

4. Shallows are places from which the luminous clouds of the upper surface are removed; but this removal itself causes them to be in some degree *hollows;* the spaces which they occupy being lower than the general surface of the sun.

They generally begin from the openings, or else branch out from shallows already formed. Sometimes their thickness, that is, their *depth*, is visible; and sometimes, also, they are unaccompanied by any opening.

5. Fig. 2 presents you with a section of the opening, where the lines *a b c d f*, corresponding with the same lines in Fig. 1, are supposed to be drawn from the eye of the observer. The line *d* passes through the opening, entirely to the main body of the sun. It is obvious, in Fig. 2, that from the position of the observer's eye, the thickness of the shallow is visible only on one side.

Fig 1

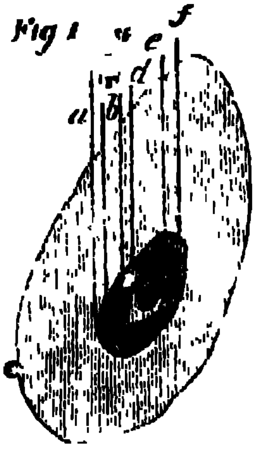
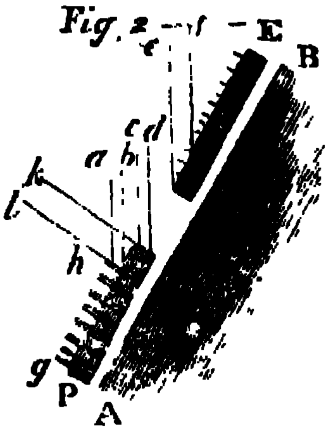


Fig. 2



6. Large openings are generally surrounded

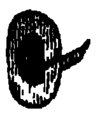
by shallows, as in the instance above; though many openings, and particularly small ones, have no shallows whatever.

7. Openings have sometimes a difference of colour, apparently because a thin veil of luminous clouds is hovering over them.

8. Openings, which are always temporary, divide when decaying, and sometimes increase after diminishing; but in general, after dividing, they diminish, and finally disappear, leaving the part of the sun's surface upon which they have been seen, more than usually disturbed.

9. Fig. 3 represents an opening, with a branch from its shallow. That opening, in the course of an hour after it had assumed the appearance which is here given to it, exchanged it for another, as you seen in Fig. 4.

Fig 3



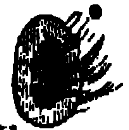
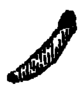


Fig 4

Fig. 5.



10. Fig. 5 is another opening, with a long

shallow. In three hours it had assumed the appearance of Fig. 6; and, in an hour after this,

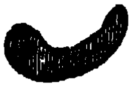


Fig. 6.

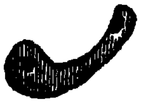


Fig. 7.

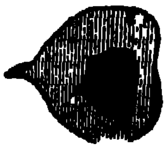


Fig. 8.

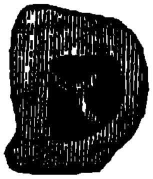


Fig. 9.

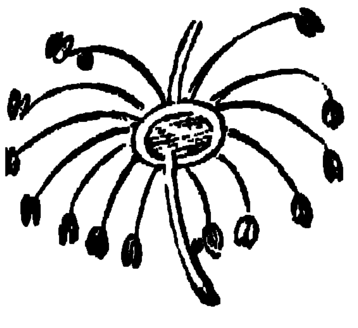
an opening appeared in the shallow, as in Fig. 7. The openings are generally at their greatest extent, as in Fig. 8, when the shallows begin to diminish, and the lips, or projections, to disappear. The division of the decaying opening is shown in Fig. 9, where the luminous passage across the opening resembles a bridge thrown over a cave.

11. Sir William Herschel imagines that the openings are occasioned by an elastic but not luminous gas, which issues through minute and commencing openings, or *pores*, and which, forcing its way through them, spreads itself on the luminous clouds, drives them out of its way, and thus widens the passage, or enlarges the

opening. But the direction of the stream of gas is often oblique or slanting; and thus the luminous clouds are drawn laterally or sidewise, and form a larger *shallow* upon one side than upon the other.

QUESTIONS.

1. Are some of the temporary appearances upon the face of the sun called, by Sir William Herschel, openings, shallows, indentations, and pores? 2. What are openings? 3. What opening was seen by Sir William Herschel on the 4th of January, 1801? What were the successive appearances of the opening of 1801? 4. What are shallows? 6. What are large openings generally surrounded by? 8. How do the appearances of openings generally terminate? 9. What were some of the successive appearances of the opening shown in Fig. 3? 10. What, in the opening, Fig. 5? When have the openings generally arrived at their greatest extent? What of the division of a decaying opening? 11. What did Sir William Herschel imagine of the cause of the openings, or black spots?



CHAP. XVI.

MORE ABOUT THE TELESCOPIC APPEARANCES OF THE SUN'S SURFACE. ABOUT THE MOVEMENTS, ALSO, OF THE SAME SURFACE.

1. FIG. 10 shows two branches of a shallow proceeding from a dark opening at the bottom of the figure. In the course of half-an-hour, one of the branches had united itself to the other, as in Fig. 11, and seemed to advance towards the opening D, while the other took the direction of the opening E. The shallow afterwards became pointed, as in Fig. 12; and in the course of an hour it became broad at the point, and a new branch broke out, as in Fig. 13.

Fig. 10.

Fig. 11.

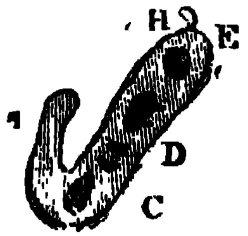


Fig. 12.

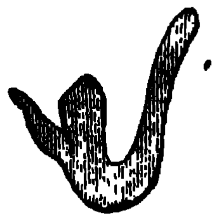
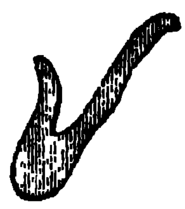
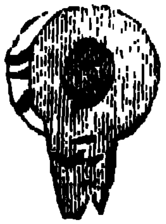


Fig. 13.



2. The new branch afterwards began to increase; and another branch, marked H in Fig. 11, began to break out from the shallow about E; and three small branches were seen to project from the shallow of the large opening in Fig. 14. The vacancies between those branches were afterwards filled up, from the same cause which occasioned their projection, so as to increase the breadth of the shallow upon that side of the opening.

Fig. 14.



3. Indentations are the dark parts of corrugations or wrinkles; and from the circumstance of their being visible very near the edge or limb of the sun, it seems that they are not much depressed below the level of the luminous clouds. The sides of the indentations (see Fig. 15) are like circular arches, with their bottoms occasionally flat.

Fig. 15.

4. Indentations are of the same nature with *shallows*, varying in size, and sometimes containing small *openings*, and at other times changing into *openings*. They extend over

the whole surface of the sun, and, with small magnifying powers, have the appearance of points.

5. Pores are small holes or openings in the low places of indentations. Sometimes they increase, and become what I am here expressly calling *openings;* and frequently, at other times, they neither increase nor last, but vanish very soon after their appearance.

6. Much of what I have now been saying, concerning the spots and other appearances in the sun, (always temporary, always changing, and sometimes, and even frequently, entirely disappearing,) may be more than you, at your age, and than many of your neighbours at all ages, can easily figure to the mind, so as to comprehend even the appearances themselves; for, as to their causes, and all the consequences to be inferred from them, these may be little, if in anywise, understood by any. But I have told you of them because I think that, to a certain extent, you will be able to form clear ideas of them; because I think they will strike and

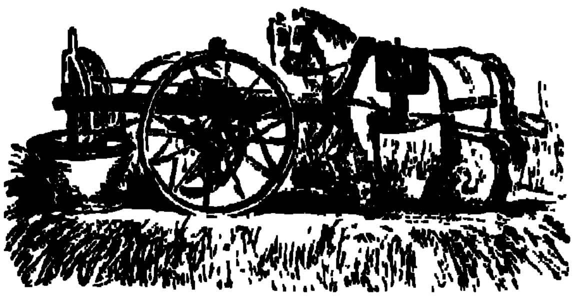
fix your imagination; and because the knowledge which they convey must necessarily both enlarge all your previous thoughts of the sun, and of the heavens in general, and correct many erroneous thoughts that, either through yourselves or others, you have hitherto entertained.

7. Look, now, at that golden disc, the sun, once more, and tell me, whether, amid all your acquired knowledge, that this apparent disc, or flat, though round, or circular body, of golden dazzling light, is, in reality, a globe; tell me whether, in the midst of that acquired knowledge, leading you thus far, it had ever also come into your head to think, that the sun was other than a body uniformly bright—unvaryingly gold all over—and besides, a settled, quiet, mass of light?

8. My dear children, the surface of the sun, besides being subject to all that variety of light and shade which I have now, in part, described to you, and to the rapid changes of those lights and shadows which you now in part imagine to yourselves; that surface, even when uniformly

bright, displays a substance constantly in motion in itself, just like the heaving sea upon our earth; a motion, too, as vehement, as uncertain, and (if I may so say) as violent and terrific. For you, and happily for us all, while, with our naked eyes, we gaze upon the flowers which the sun enlightens, and while, with only those naked eyes to open, we pursue our path over the hills, and through the valleys, warmed, cheered, and guided by its presence, we think of the surface of the sun as only of a shining glassy surface, like that of the calm sea or river! But, my children, the surface of the sun is all that time in violent activity; its substance is in extreme commotion; it has waves rising and falling, and currents pouring this way and that; and, tranquil as we, at our fortunate distance, and with our fortunate small capacity of natural vision, are able to be, and to feel ourselves, beneath the tempest always prevailing in our great luminary, the surface of the sun, during the whole time, has really greater resemblance to that of the ocean, when at once the winds blow hurricanes, and the light shines upon its green billows and their snowy foam; or, rather, (when all is bright, though restless, upon the surface of the sun,) like what you may fancy of a sea of molten gold, tossing and heaving, high and low, and toward this side, and toward that!

9. Such is the sight which, through the telescope, the sun offers us of its own surface, even when bright all over, or without the smallest or the faintest spot of darkness or of shade; but how happy, that through our simply natural vision, we know nothing of all this turmoil above us, while by its placid or its glorious lustre, we pursue, daily, our pleasures or our labours!



CHAP. XVII.

ABOUT WEIGHING THE SUN. HOW MANY TIMES THE SUN IS HEAVIER THAN THE EARTH.

1. I COPY the following sentences, about weighing the sun, and about how much the sun is heavier than the earth, and how much the earth is lighter than the sun, from a note in Mrs. Somerville's very excellent book, called the Connexion of the Physical Sciences. They will at least make my little readers "prick up their ears," and also give them a specimen of what extraordinary things are to be learned among the sciences even now, and may yet add to the amount.

2. "As hardly anything," says Mrs. Somerville, "appears more impossible than that man should have been able to weigh the sun as it were in scales, and the earth in a balance, the method of doing so may have some interest. The attraction of the sun is as the quantity of

matter in the sun to the quantity of matter in the earth; and, as the force of this reciprocal attraction is assured by its effects, the space the earth would fall through in a second by the sun's attraction, is, to the space the sun would fall through by the earth's attraction, as the mass of the sun to the mass of the earth. Thus the weight of the sun would be known, if the lengths of these two spaces can be found in miles, or parts of miles. Nothing can be easier;" and, here, the fair but profound philosopher, whom I quote, first remarking, that the distance from the centre of the earth to the surface of the earth is four thousand miles, but the distance from the surface of the earth to the surface of the sun, ninety-five millions of miles, and some other things, calmly and justly assures us, that all the rest comes naturally, "by a single question in the rule of three!"

3. After this, and after stating to us how to work the sum—"By this simple process," she concludes, "it is found, that if the sun were placed in one scale of a balance, it would

require three hundred and fifty-four thousand, nine hundred and thirty-six earths to form a counterpoise."

4. That is, that the sun is three hundred and fifty-four thousand, nine hundred and thirty-six times as heavy as the earth; or, that the earth is three hundred and fifty-four thousand, nine hundred and thirty-six times as light* as the sun.

5. But all this, as you see, is only a comparative reckoning. Neither Mrs. Somerville (learned as that excellent lady is) nor anybody else, however learned or excellent, can answer us either of the previous questions—how heavy is the sun? or, how light the earth? So that we are still without a chance of knowing, either in pounds troy, or in pounds avoirdupoise, or in tons, or in hundred-weights, what either the sun or the earth absolutely *weighs;* which is what I am afraid you expected to hear when I

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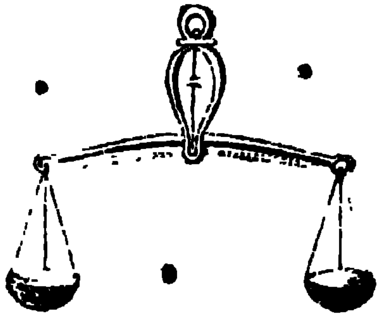
* I need not here remind my little readers, that the word *light* is employed to signify the reverse of *heavy*, as well as the reverse of *dark*.

began my chapter, and when you found my author talking of our being able to "weigh the sun as it were in scales, and the earth in a balance;"—assuring us that "nothing can be easier;" and promising to set before us "the method." She teaches us, indeed, how to weigh one heavenly body against another; but not what it is that any one of those bodies absolutely *weighs*. By the same process as in the present case, we shall compare, by and by, the weight of the sun with the smallest of the satellites of Jupiter.



CHAP. XVIII.

SOMETHING MORE ABOUT SUNLIGHT.

Orpheus singing to his lyre the praises of the sun.

1. I REMARKED to you lately, that we can look with our naked eyes, or through a clear glass, at the moon, but that we cannot look so at the

sun; and that is one of the proofs of the great superiority of the light of the sun, as compared with the light of the moon. I may now add, that the light of the sun is reckoned to exceed that of the full moon by three hundred thousand times.

2. Dr. Wollaston, indeed, made the difference more than eight hundred thousand times; or more than double this amount. He computed the light of the sun as being equal to the light of five hundred and sixty-three candles, placed at twelve inches distance from the eye; and the light of each of these candles, at that distance, as being equal to the light of one hundred and forty-four moons. From all which he inferred, that the light of the sun exceeds the light of the moon by eight hundred thousand and seventy-two times!

3. My book, however, would grow very large, did I attempt to tell you a thousandth part of the uses of the light, either of the sun, or of the moon!

4. I have mentioned, hitherto, only a part of

its uses for the purpose of human science, art, and industry. But what should I not have to say, if I reminded you but ever so little of its uses to the wants and movements of the myriads of other living creatures; and still more, if I did but begin to talk of its importance to the operations of nature itself?

5. The light of the sun is found to be necessary both for the colours and for the forms of bodies. Plants, animals, and even men and women and children, kept unnaturally in the dark, grow pale, ill-coloured, and deformed.

6. It even appears, from a remarkable anecdote set down by the late Sir Humphry Davy, that bright colours cannot be so much as *manufactured*, in the absence of a bright sky!

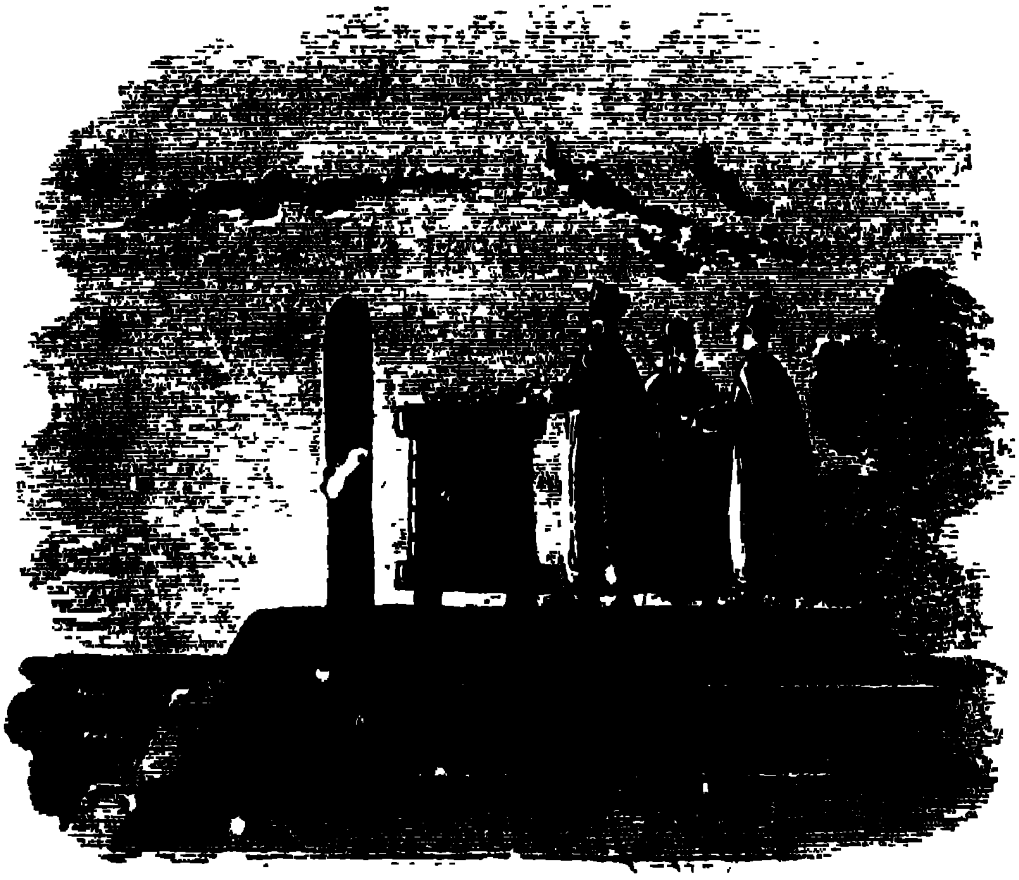
7. Light is commonly thought cheerful; that is, it enlivens or invigorates the things that enjoy it. But this is not merely because it pleases the eye, but because it brings with it something (probably oxygen) which influences the nerves both of animals and plants.

8. Thus, things naturally blind, or such as

have the misfortune to become so, are still far from being denied, even in their own bodies, many of the blessings of light; and the Negro, in South America, who daily carried his aged mother into the sun, because, as he said, "it did her good," was not perhaps aware of all the ways in which the light of the sun really "did good" to his feeble parent. It was not the warmth only of the sun that "did her good," but doubtless some strengthening attendant or attendants upon the light, in addition to the warmth!

9. I might here be tempted to make quotations in praise of the sun, but I content myself with remarking, that after being told of only a few of these admirable and affecting things of the sun, you will less wonder that an eloquent English writer has found a poetical similitude, for the loud rejoicings of an English village multitude, or in "the shouts of a Persian army, at the rising of the sun;"—or, that it should have been fabled of Orpheus, how the holy bard, at the dawn of every morning, ascended

to the top of a high mountain, to see the earliest sight of the rising sun, upon the wave or upon the plain below, and to welcome it with hymns of praise;—or, that with ruder devotion, the priests of Mexico, on the tops of their terraced pyramids, offered sacrifices of quails to the first beams of the ascending or returning sun.



CHAP. XIX.

ABOUT THE CHANGES OF THE MOON.

1. Now that we have in some degree considered the sun, we may talk again of the changes of the moon, or changes of its phases or appearances. They depend upon the sun.

2. I have told you that the moon is a large round body, with an uneven surface. Its bulk is nearly a fiftieth part as large as the earth; and is two hundred and forty thousand miles distant. If a swift bird could fly constantly from the earth toward the moon, it would perform the journey, from the one to the other, in eighty days and nights.

3. Different measurements are stated of the moon, according to different considerations. Its diameter, or the measure of a line which should be carried entirely through it, from side to side, at its equator, is called from two thousand one hundred and sixty miles, to two thousand one

hundred and eighty; and, since the earth, similarly measured, is less than eight thousand miles, therefore the *diameter* of the moon is much more than equal to a fourth part of that of the earth. But the moon, measured as to the side or surface of the disc which it presents to the earth, is only equal to a thirteenth part of the earth, respecting the same *surface;* and further, the moon, measured as to its bulk or *volume*, or, by other terms, its total magnitude or size, is equal to no more than a forty-eighth, or less than a fiftieth, of the bulk or volume of the earth; and, finally, measured as to its *mass*, which means the quantity of matter it contains, it is only equal to about a seventy-fifth part of the mass, or amount of matter, that is contained in the earth.

4. I have told you that the moon turns on its axis once in about twenty-nine days and a half, and revolves round the earth in the same period of time; and, further on, I shall explain both those motions. You have observed that the moon sometimes appears round, and sometimes only partly round. I have before spoken of

these changes, and I am now going to tell you their reason.

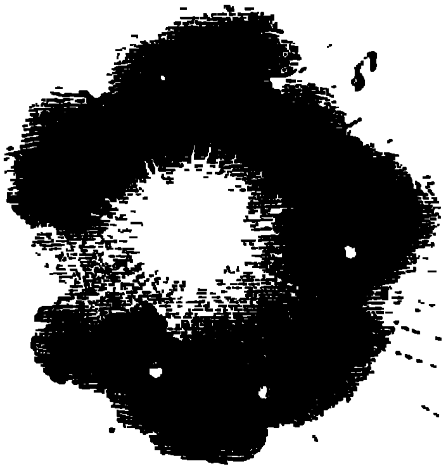
5. The moon is a dark body, and therefore cannot shine of itself; but the sun shines upon it, and makes it bright, and then the moon shines upon the earth.

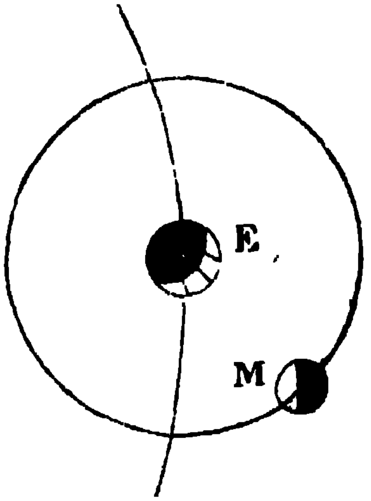
6. But you will ask me how the sun can shine upon the moon when it is night, and the sun is gone? You must remember, that although the sun is gone from us at night, yet the sun really exists, at the same time, at a great distance, round the other side of the earth. There it is always shining; and thus, from the situation of the moon, (though our part of the earth is then gone or turned away from the sun,) it still lights the moon, and renders it visible to us, and is the means of shedding moonlight upon the earth.

7. Well! sometimes the sun shines upon one side of the moon, and sometimes upon the other. When one side of the moon is bright, the other is dark. We see but one same side of the moon, and we can see only so much of that as the sun shines upon. Sometimes, we can see only the

edge of the light which the sun casts upon the moon. Then it looks like a bow in the sky, and we call it the new moon.

8. The next night we can see a little more of the light on the moon; and the next night more, and the next more still; till at length the sun shines upon the whole of that side of the moon which is always turned towards us, and the moon appears round or full.



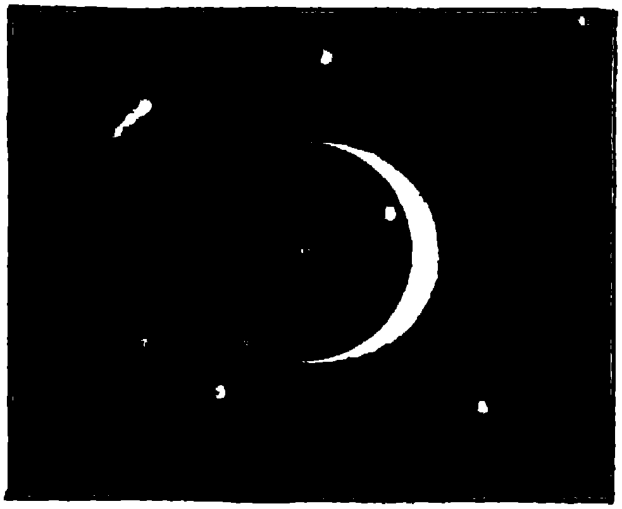


9. Here is a picture of the sun shining upon the moon, and the moon shining upon the earth. I am obliged to draw it as if the side of the earth that is next the sun were dark; but you will understand that the sun is more *behind* the

earth than I can make it appear upon paper, and that therefore the light side of the earth is really toward the sun. You remember that the moon is constantly passing round the earth, though without changing the side that it shows us; and that therefore its situation, with respect to us, is constantly changing. It is owing to these changes of situation of the moon, that these various appearances, which I have just described, take place. Now you will remember, that the moon is a great dark round body that does not shine of itself. It receives its light from the sun. The light which it sheds upon the earth consists only of that which is shed upon it by the sun, and reflected by it upon the earth. You will remember, that the different phases or appearances of the moon arise from its different situations at different times.

10. These different *appearances* of the moon are called its different *phases.* How they are thus produced by the different situations of the moon, as it moves round the earth, while both the moon and earth are illuminated by the sun, you have seen in the picture at page 41.

11. You must now look back to my Frontispiece. It shows you the moon, as, in very clear weather, you may see it when it is three or four days old, or at the beginning of the *phase* of its first quarter; and when, besides the ash-coloured light of what is still to be called the *dark* part of its body, you may see a fine ring of light round its *dark* side; and when, also, you may see a phenomenon similar to that displayed in this figure of the planet Mercury, which I shall repeat in its proper place: namely, that the bright *crescent* appears part of a larger globe than that composing the dark body.



12. You will learn from this, that the phases of all the planets (Mercury being one) which,

like the moon, move between the earth and the sun, appear to the earth with precisely the same phenomena of phases as the moon. They change according to the place of the planet in its orbit; and, when their illuminated parts are at the smallest, still the remaining or *dark* parts of their bodies preserve that degree of ash-coloured light which is sufficient to make them proportionably visible. But how is this, then, to be reconciled with the doctrine, that the moon derives its ash-coloured light from its reflection of the light of the earth? From what reflection do Venus and Mercury derive their same ash-coloured lights?

13. There is still, however, another phenomenon observed in all these cases, and one which, with respect to the moon, has equally the attention of the multitude and sage. It is, that the light part of the planet appears of larger proportion than the dark; or, as if the light part formed a division of a larger disc, or larger circle, than that to which the dark part is pertaining; or, as if the disc or circle of the light part

were large enough to embrace or contain the disc or circle of the dark part.

14. But this appearance of containing, or of embracing, has suggested, as is usual, to the multitude, a figurative or poetical description of the appearance. They say, with respect to the moon, which is their conspicuous example, that we have here—"The Young Moon with the Old one in her arms."

15. The sage, in the meantime, (the philosopher,) inquires for the *cause* of this appearance; and he finds it in the superior dimension which, to the eye, every light-coloured *object*—and therefore light-coloured *part* of an object—assumes, in comparison with dark-coloured objects or their parts. This, therefore is a question of optics, or of the theory of sight or vision. You are yourselves well acquainted with the circumstance, that men, and women, and children look larger in white clothes than in black; and in this you have one of the many easy examples of the truth of what I am saying.

QUESTIONS.

4. How long does it take the moon to turn round on its axis? How long does it take the moon to revolve round the earth? Does the moon always appear round? Describe the moon's various appearances. 5. Does the moon shine of itself like a candle, or not? 6. Why does it shine? Where does the sun shine in the night? 7. Does the sun shine at one time upon all parts of the moon? Can we see that part of the moon that is not lighted by the sun? What part of the moon do we see? What causes the new moon, as it is called? 8. What causes the full moon, as it is called? 9. What causes the various appearances of the moon? What is the light of the moon? 10. What are the phases of the moon?

CHAP. XX.

ABOUT THE HARVEST MOON, AND ABOUT THE HUNTER'S MOON. ORDINARY CHANGES OF TIME FOR THE RISING OF THE MOON.

1. But there are exceptions to the general order of the monthly changes of the moon; among them those that are productive of the phenomena of the Harvest Moon and Hunter's Moon.

2. Every autumn you will be likely to hear people talk of the Harvest Moon, and the Hunter's Moon; and sometimes as if they were larger and more bright and beautiful than other moons.

3. The Harvest Moon is seen in harvest-time, and favours the labours of the husbandman; and the Hunter's Moon is that of the succeeding month, and has its name from the light which it offers to such as hunt by moonlight the wild beasts of the forest.

4. The Harvest Moon merely extends the number of the hours of light during which the

husbandman may either reap his corn or carry it from off the field; and the phenomenon has

been so distinctly analysed, and physically so perfectly accounted for, that astronomical principles are laid down, explaining, beforehand, why, and in what years, there should, and always actually will be experienced, the Harvest Moons that are called those *most beneficial* to the husbandman: and why, in other certain years, there should, and actually will be experienced, the Harvest Moons *least beneficial;* that is, the Harvest Moons that yield either the *most* or the *least* of their distinguishing and early light. The Harvest Moon rises at the time of sunset; and, what it is that is so striking, as to the Harvest Moon, and as to the Hunter's Moon, is, that the moon, at the season I am speaking of, instead of rising, as is usual, about fifty minutes later every evening than it rose the evening before, now rises, or rather seems to rise, for several evenings together, at the same time each evening.

5. What increases their value also, both the Harvest Moon and the Hunter's Moon are Full Moons; that is, the moon is full at the times when it receives these names. They are two Full Moons, which, one after the other, rise, for nearly a week's continuance each, at the setting of the sun.

6. Now the cause is the peculiar position of the orbit of the moon, in respect of the equator of the earth, at the time when the moon is at its *full.* The orbit is in the same position at some time during every month throughout the year; but it is only in the two months in question, that

it comes into this position at the time when the moon is at its *full;* and hence its continued rising at the same hour (and this an early hour) is taken notice of at these times, and not at others.

7. It is, therefore, but in the *fulling* of the moon, at the time when, in these two successive months, its orbit has assumed a peculiar but monthly position, that consists the cause of the phenomena of the Harvest and Hunter's Moons, and not in any separate circumstance belonging to the order of the lunar risings.

8. There seems little danger, in the mean time, of our mistaking the purpose of this autumnal departure from the general order, or autumnal arrangement for the adaptation of this order to the production of the phenomena of which we are speaking; and surely both the purpose and the means are here among the finest examples I could readily adduce to you, of the establishment of the laws of creation for the benefit of its creatures!

9. There is a somewhat kindred phenomenon

experienced the more forcibly the more we approach to the Pole, consisting in a wonderful adaptation of the path of the moon in the heaven, so that a greater share of moonlight is enjoyed in winter than in summer; while, in the regions of the Equator, where the sun is in equal power throughout the year, there is no more moonlight at one season than at another!

CHAP. XXI.

MORE ABOUT THE HARVEST MOON, AND ABOUT THE HUNTER'S MOON.

1. My little readers must be grown bigger, and better acquainted with the science of astronomy, before it can be of any use to attempt explaining to them those niceties concerning the changes —not of the moon—but of its *orbit*, which minutely account for what I have just been speaking of; but I may mention, even now, that if it were not for these changes in the position of the moon's *orbit*, the moon, as usual, would rise exactly fifty minutes later every night or evening; because the moon moves from east to west in its orbit about thirteen degrees every day; a space which it overruns in the fifty minutes here referred to. Whereas, from the autumnal change of position in the moon's *orbit*, it comes to pass, that, at times, the moon as it appears to us, is so long as an hour and seventeen minutes, (or

seventy-seven minutes,) and at other times so quick as seventeen minutes, in overruning the thirteen degrees; and is, therefore, at times seventy-seven minutes—and at other times only seventeen minutes—in performing the same journey. Now, it is because the change, for several successive evenings, at the times of the *full moons* that I speak of, is really no more than the unusually short period of *seventeen minutes;* that therefore the time *appears* to be the same, or to have no change whatever.

2. But there is also another variation, and to this, too, I have already alluded. At one period in the course of the changes of the position of the moon's orbit, the Harvest Moon, as well as the Hunter's Moon, will rise, upon the successive evenings, more nearly at the same time than at other periods; and, at this period of greatest uniformity, the Harvest Moons are said to be those *most beneficial* to the husbandman. When, however, nine years, and a hundred and twelve days, have next elapsed, the Harvest Moons, for another period, fail to rise

so nearly at the same time upon each evening; and it is then that they are said to be those *the least beneficial.*

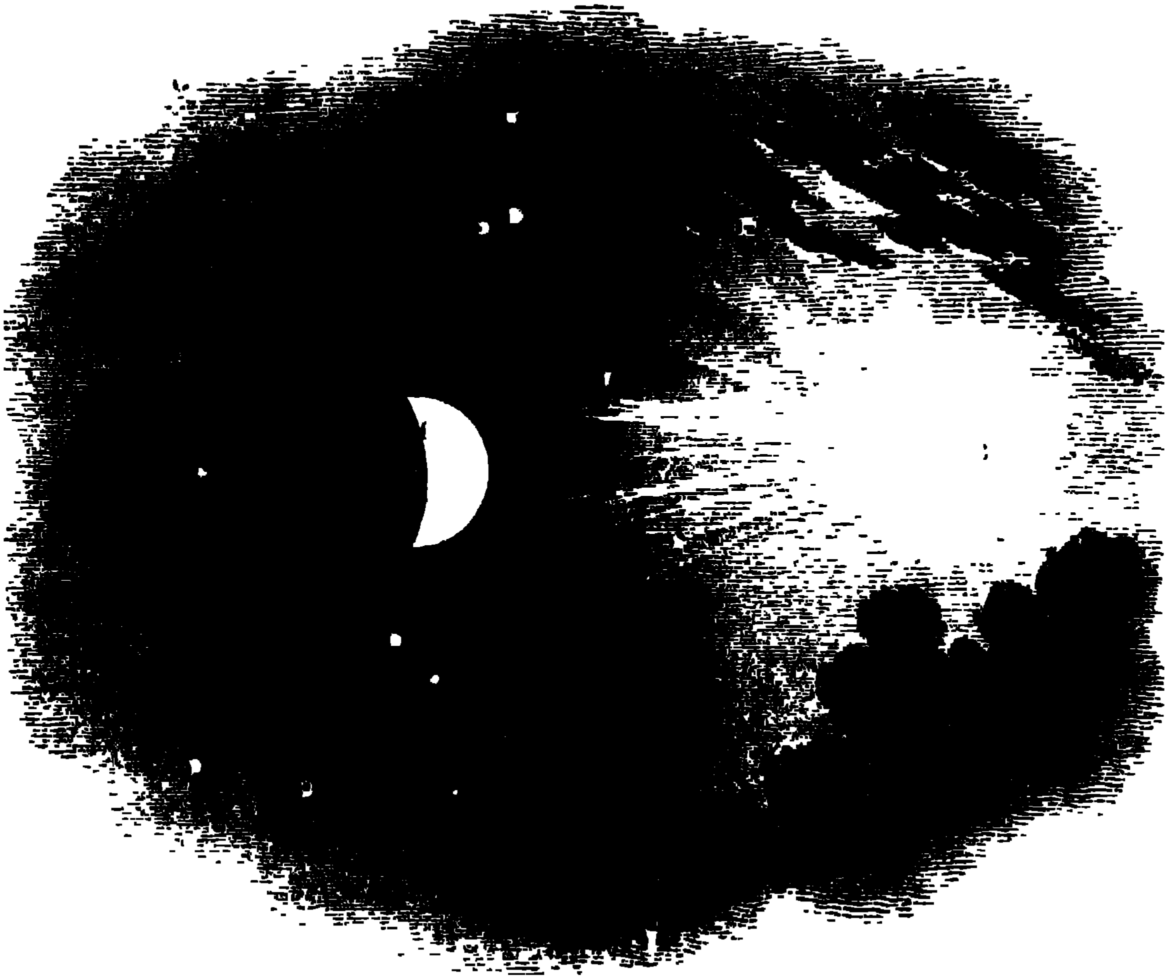
3. Astronomers, as I have said, are able to tell us of them before they come, as well as to say when they formerly happened. Thus, as in the instances following, some past, some coming, here are years in which the *Harvest Moons* were or will be *least beneficial*—and in which years, also past or coming, they were or will be *most* so. The years 1812, 1831, and 1849, are set down for years in which the Harvest Moons were or will be *least* beneficial; and the years 1802, 1820, 1839, and 1857, for those in which there were or will be Harvest Moons of the class *most* beneficial.

QUESTIONS.

2. When are the Harvest Moons said to be *most beneficial?* When are they said to be *least beneficial?* 3. Are their appearances and returns capable of nice calculation? What lesson, as to creation, does their regularity afford? In what years, lately passed, or shortly to come, have the Harvest Moons been, or will be, *least beneficial?* In what years *most beneficial?*

CHAP. XXII.

PARLEY TELLS ABOUT ECLIPSES.



1. I HOPE you have not forgotten, that the earth makes a great circuit round the sun every year, and that the moon revolves round the earth once

in twenty-nine days and a half. Now it sometimes happens, that in these various revolutions, the moon gets directly between the earth and the sun.

2. And what do you think is the effect of this? Why, the moon, thus coming between the earth and sun, interrupts the light of the sun, and produces what is called an eclipse. At the beginning of this chapter is a picture which represents the moon between the earth and the sun. You will perceive that the earth is dark, as if it were night.

3. I have seen several eclipses in my time. Sometimes they are partial; that is, the moon only comes partly between the earth and sun, and does not entirely darken it. Sometimes the moon comes exactly between the earth and sun, and then the eclipse is total.

4. I remember a total eclipse about twenty years ago. I must tell you, that learned men who have studied the motions of the heavenly bodies can calculate when an eclipse is to happen, or has happened. Well! before the

eclipse of which I am speaking took place, they had discovered that the sun was to be eclipsed on a particular day.

5. Some ignorant people disbelieved this altogether; but most persons knew that the eclipse would really take place, as predicted by the astronomers. So, when the day came, almost everybody was full of expectation.

6. It was a beautiful bright day. About ten o'clock in the morning the eclipse began. On looking through a piece of smoked glass, it appeared as if a little piece was gone from the edge of the sun. This piece grew gradually larger, and, by and by, it was evident that the air began to be darkened.

7. In a short time; only the edge of the sun could be seen, and at length it was totally covered. It was now near noon, there was not a cloud in the sky, and yet the sun was not visible!

8. The air grew chill, as if it were evening; the whole face of nature was dark, as at the evening twilight; the birds ceased their songs,

and retired to rest. I well remember to have seen an old hen, apparently much disturbed, retire to her accustomed shelter, where she gathered her brood of twelve chickens under her wing, as if for the night.

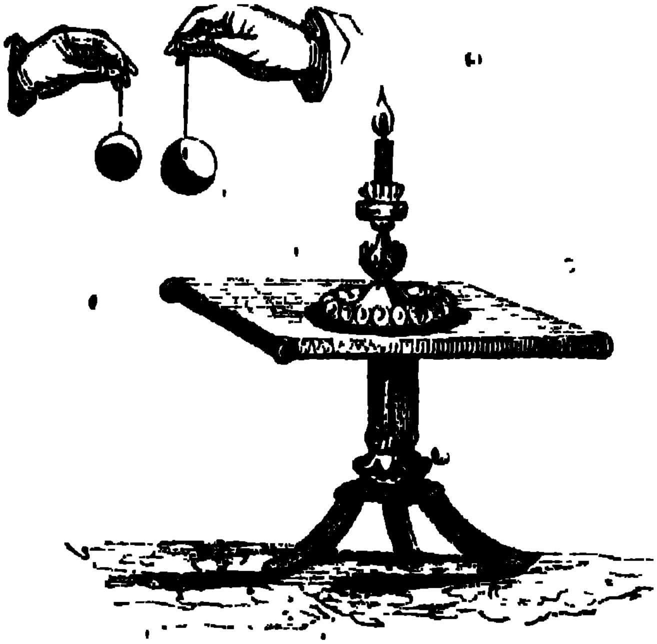
9. It was a solemn time, and of a nature to make us feel our dependence upon that great Being who directs the movements of the sun, the moon, and the earth through the skies. But for his care, how soon might the sun be removed from its place, and an everlasting night cast its shadows over our world!

10. But the eclipse did not last long. In a few minutes the sun again appeared. At first we could only see the edge of the sun. Then we could see a little more, and by and by, the moon had passed entirely over its face, and the sun shone forth as bright as ever.

11. I have spoken, thus far, of *eclipses of the sun*, produced by the passage of the moon between the sun and the earth; but there are also *eclipses of the moon*, produced by the passage of the earth between the sun and the moon.

12. Since the moon moves round the earth, she will, as we have already seen, at one point of her orbit, come between the earth and the sun, and thus conceal the sun from our view; but at the opposite point of her orbit, the earth will be between her and the sun, and will cast a strong shadow upon her: the former case we call an eclipse of the sun; the latter, an eclipse of the moon.

13. To give you a clearer idea of the subject, let us suppose this candle to represent the sun, and the two balls, which are suspended by

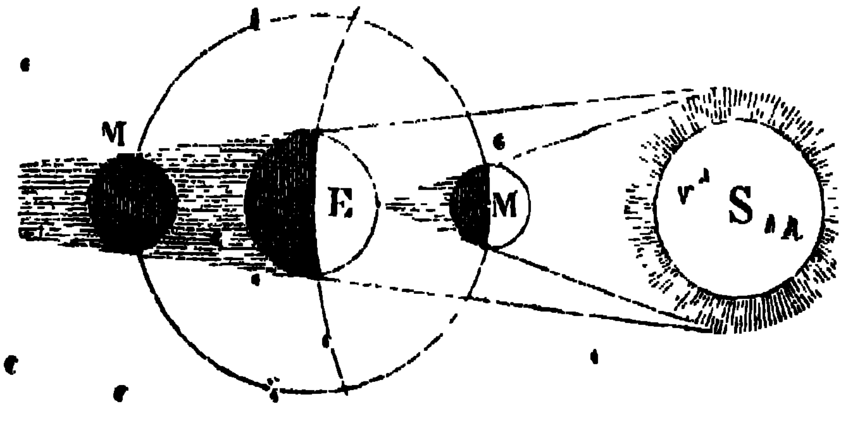


threads at different distances from it, to represent the earth and moon. I place the three in a direct line, the larger ball at about eight inches from the candle, and the smaller about two inches beyond the larger. In this position they exhibit in miniature a total eclipse of the moon; for you plainly perceive that the larger ball prevents the light of the candle from shining on the smaller one, which is thus immersed in a deep shadow. If now I raise the smaller ball a little, you observe a portion of the light from the candle falls upon its upper part, while the lower part is still in the shadow, thus representing a partial eclipse.

14. From this, it will be plain to you, that by changing the situation of the smaller ball, and bringing it between the larger one and the candle, in a direct line, a total eclipse of the sun would be represented; but as the moon is so much smaller than the sun, we always observe in this case a ring of light surrounding the darkened part; on which account such an eclipse

of the sun is termed an annular eclipse. An eclipse of the sun can only happen at the time of a new moon; and an eclipse of the moon can never take place but at the time of the full.

15. But here is a further figure, representing the doctrine of the eclipses, which you will readily comprehend, if you have attended to my remarks; and this figure shows also, at one view, the manner of the eclipses, both of sun and moon. Let S represent the sun, E the



earth, and M M the moon, it is obvious, that when the moon is in a line between the earth and the sun, she will conceal part of that luminary from the view of the spectators on the earth's surface; and, on the contrary, when the earth is in a line between the sun and the moon, the moon will be immersed in the dark shadow of the earth.

QUESTIONS.

2. What causes an eclipse of the sun? 3. What is a partial eclipse? What is a total eclipse? 4. Will you give an account of an eclipse of the sun, that Parley witnessed about twenty years ago?

CHAP. XXIII.

SOMETHING MORE ABOUT ECLIPSES.

1. THE eclipse of which I have now told you was an eclipse of the sun; that is, the moon came between the earth and sun, and prevented the sun from shining on the earth. A total eclipse of the sun does not frequently happen. Sometimes, too, an eclipse takes place in one country and not in another.

2. For instance, suppose an eclipse of the sun to take place in China about noon. Now, you

remember, that when it is noon in China, it is about four o'clock in the morning with us. Of course the eclipse of the sun in China might not be visible here, for, at the time of the eclipse, the sun might not have risen here.

3. But sometimes the earth gets exactly between the sun and moon. The consequence of this is, that the moon is eclipsed. The earth being between the sun and moon, prevents the sun from shining on the moon, or deprives the moon of its light.

4. The moon being deprived of its light, cannot shine upon the earth. Eclipses of the moon are much more frequent than eclipses of the sun. I have seen many eclipses of the moon. It is interesting to witness them; but they are not so striking as eclipses of the sun.

5. Some of the other planets are subject to eclipses. In the various movements of these heavenly bodies round the sun, one planet occasionally passes between the sun and another planet, and thus transiently deprives it

of the light for which it is dependent upon that great luminary.

QUESTIONS.

2. Can an eclipse of the sun in China, be seen here? Why not? 3. What causes an eclipse of the moon? 5. Do eclipses ever happen to the other planets? How?

CHAP. XXIV.

A WORD OR TWO MORE ABOUT THE ECLIPSES OF THE SUN. CENTRAL ECLIPSES. TOTAL ECLIPSES. ANNULAR ECLIPSES.

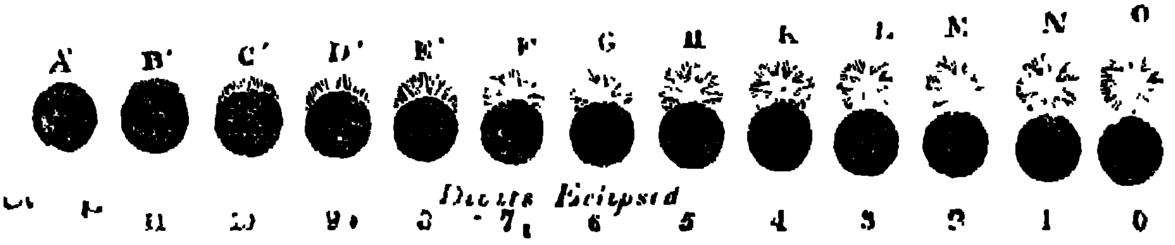
1. Now that we are again talking of the sun, I will add a little to what I have already said concerning its eclipses.

2. You understand that an eclipse of the sun, or the hiding of a greater or less proportion of the whole face of the sun, from that part of the earth upon which the eclipse is seen, has its cause in the passing, either of the whole of the moon, or of a part of the moon, between the earth and the sun. You understand that all the three great bodies (the earth, the moon, and the

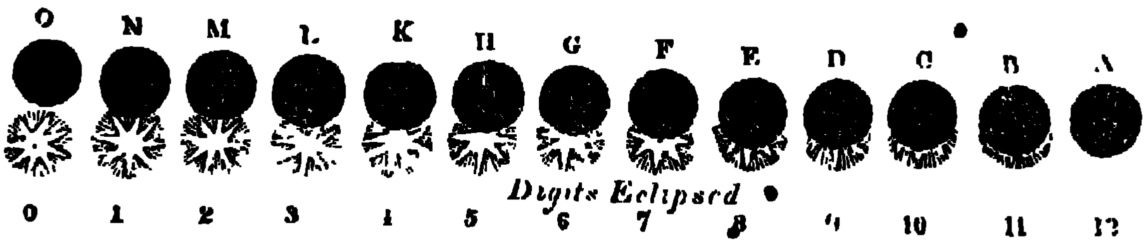
sun) are at immense distances from each other, and the moon between the other two; so that the moon, when, in whole or in part, it passes between the earth and the sun, will hide the sun from some part or other of the earth; just as, while you run across the grass-plot, you hide the flowers, moment after moment, from some part of the company. And this hiding is eclipsing.

3. The figures which I place below will answer the double purpose of showing you, first, the progress of a *total eclipse*, from its beginning to its end; and secondly, the great variety of *partial eclipses*, or such eclipses as, from their beginning to their end, are only eclipses of a *part* of the sun's disc.

4. In my first figure the dark bodies represent



the moon at each point of its progress between the sun and the earth. You observe that the line or path of the moon is not the same with that of the sun; or that, in other words, the first makes an angle with the second; but, for this reason, the moon, during the eclipse, alternately eclipses all parts of the sun's surface; beginning below the sun, as at o in this series from o to A; and ending above it, as at o in my second figure, or the same series reversed, or running from A to o.



5. The numerals which form the lowest line in each of my figures, show the number of *digits* of the sun's disc which the moon eclipses at each point. Astronomers divide the disc of the sun into twelve measures, parts, or *digits*, so that when they say three digits of the sun's disc are eclipsed or hidden, they mean that a

quarter of the whole is so eclipsed; and when they say that six digits are eclipsed, that one half of the sun's face or disc is covered.

6. Under O, in my first figure, where the moon has not yet eclipsed any part of the sun's disc, you find the cipher 0, implying that not a single digit of the sun's disc is yet eclipsed. But at N it has eclipsed 1 digit; at C 10; and at A 12, or the whole disc.

7. In like manner, when the eclipse is in progress towards its end; which progress begins the moment after its completion; at A in my second figure, (which is only a repetition of A in my first figure,) you see the complete eclipse, or the covering of 12 digits; while at B, the moon has already ceased to eclipse more than 11 digits; at N eclipses but 1 digit; and at O covers 0 digit, or has entirely departed from between the earth and sun.

8. And the whole passage, or whole eclipse, occupies but a short space of time. When the eclipse is total, the whole twelve digits of the sun's disc being eclipsed, this absolutely total

eclipse lasts only the third part of a minute. But the sensible darkness is certainly of longer continuance; that is, of some few *minutes* duration; because we may reckon it as lasting from E to A in my first figure, and from A to E in my second.

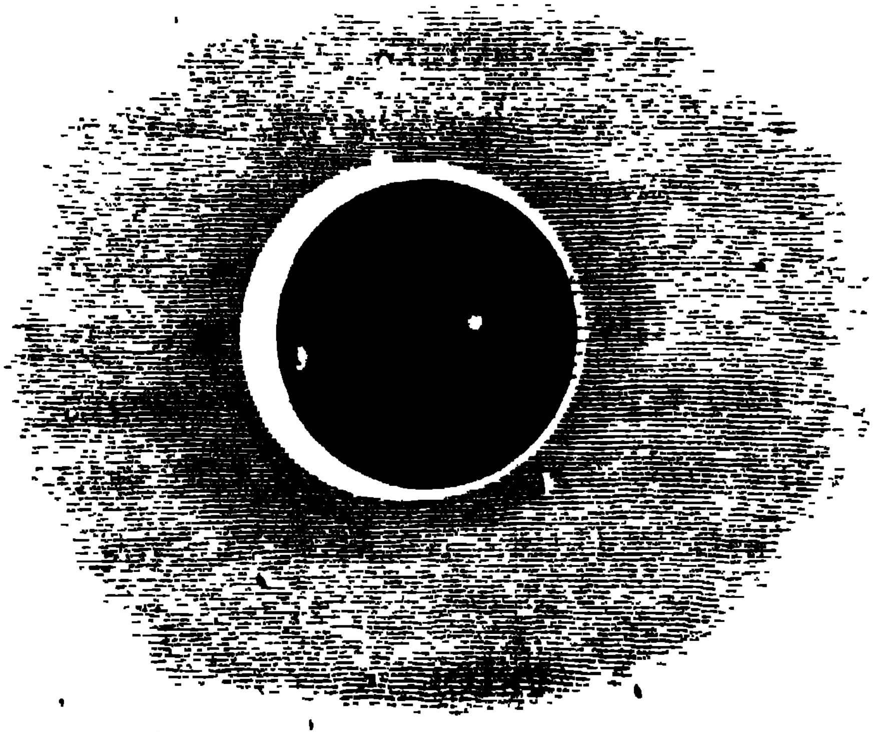
9. At E, in either figure, you see that 8 digits of the sun's disc is eclipsed; that is, two-thirds of its whole space.

10. The velocity of the whole, in the meantime, is great; that is, the eclipse, when once begun, is soon over. The darkness which it occasions upon the earth, consists of the moon's shadow upon the earth. But in four minutes of time the moon carries her shadow quite over any place which it touches in the greatest darkness of the eclipse. The moon's shadow travels at the rate of thirty degrees and a half, or eighteen hundred and thirty geographical miles in an hour, or thirty miles and a half in a minute; which is almost as swift as the motion of a cannon-ball.

11. A total eclipse is a *central eclipse.*

That is, in such an eclipse, the centre of the moon passes between the earth and the centre of the sun. But every central eclipse is not a *total eclipse.*

12. A central eclipse may be an *annular*



eclipse; that is, though, for the moment, the centre of the moon is placed immediately in front of the centre of the sun, yet the moon may not be in such a situation as to allow it to hide from us the whole surface of the sun, or its twelve digits. In that case, so much of the sun's disc as is not eclipsed will be seen to surround the moon *annularly*, or in the manner of a *ring;* and how this variation happens, I am going to explain.

13. If your brother's hat is held before his eyes in a situation very near to his face, that small hat will be sufficient to hide or *eclipse* from him a great castle. This, then, is a central and *total* eclipse.

14. If it is held a little further off, but still straight before his eyes, it will no longer hide or eclipse the whole of the castle; for a part of the castle will appear round the whole circle of his hat. This, then, is a central and *annular* eclipse.

15. Thus, it is no change of size in the moon, any more than in the hat, which causes the change of its capacity totally to hide or eclipse the sun; but only the change of its place, or the degree in which it is near or distant from the earth, at the time of its passing between the earth and the sun.

16. But, further, there is always a possibi-

lity, both of an annular eclipse, and of a total eclipse which is not central.

17. My figure, at two pages back, represents the central and annular eclipse of the 15th of May, 1836; but that eclipse was thus seen only in a small part of the British Islands, and of some other countries. The figure shows the moon not yet arrived exactly in the centre of the sun. The small black lines which appeared to connect, for a moment, the right edge of the moon with the right edge of the sun were optical illusions.

18. Here you see a clever and good-natured little boy, who, having smoked a piece of glass

against the time of the eclipse, that himself and his smaller sister might have a nice view of it when it came, is now holding it before the one eye which she keeps open, both to enable her to see, and to prove that his glass has been smoked just as it ought to be. For you must know that his sister is a little awkward in using it; and has two or three times dazzled her eyes sadly, by looking on one side of it, instead of through it!

19. By the side of my infant astronomers is a tame raven, which, rather more affected than they by the sun's dimness, but less curious as to the particulars, has put his bill under his wing, to take a nap.

QUESTIONS.

4. What does Parley explain further about eclipses of the sun? 5. Into how many parts do astronomers divide the disc of the sun? What are those parts called? 11. Are central eclipses always total? 12. What is an annular eclipse?

CHAP. XXV.

WHY THE SUN AND MOON APPEAR LARGER WHEN ON OR NEAR THE HORIZON, OR AT THEIR RISING AND SETTING, THAN WHEN IN THE ZENITH, OR IN THE MIDDLE OF THEIR COURSES.

1. You expect me to tell you how it happens, that the sun and moon, as seen in different parts of the heavens, appear to vary in their sizes. I am glad to know that you pay attention to these changes in natural appearances, and give your minds to understanding their causes; but these apparent changes of magnitude of the sun and moon, it seems to be much thought, do not admit of scientific explanation, and have no cause but in our modes of judging of the magnitude of bodies with our eyes, according as those bodies have or have not any other bodies near them, by the help of which we can form comparisons.

2. Your question, in the meantime, is one which is often asked by persons much older,

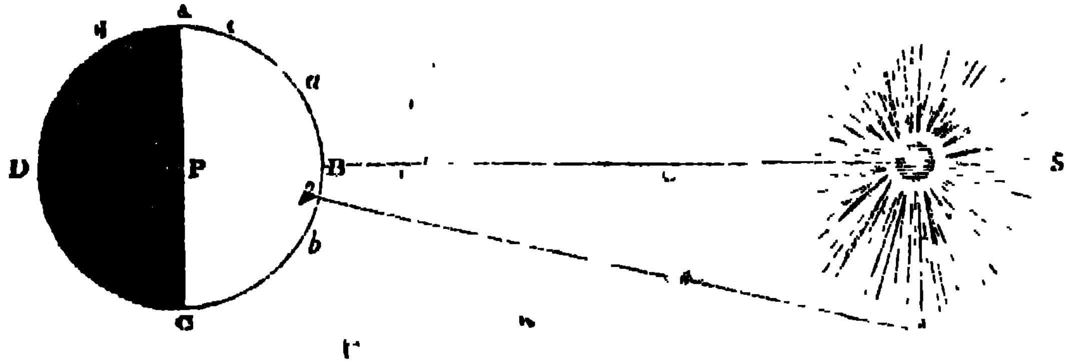
and wiser than yourselves. Eminent philosophers, astronomers, and mathematicians have proposed several and very different explanations.

3. I have no doubt but that you, like other persons, have been inclined to fancy, that the sun or moon, when on or near the horizon (that is, when they really seem nearer to the *earth*, or to the landscape,) appears larger to you than when they are in the middle sky, precisely because they are actually nearer to *you;* just as your dog, or your horse, or a ship, or a coach, or a *balloon*, seem larger when they are near you, than when they are farther off.

4. But the reverse is really true. Though the space of four thousand miles (as much, however, as half the diameter of the globe we live on) is an insignificant space, when we are talking of the distances of heavenly bodies, yet, upon this occasion it is worthy to be noted, that the sun and moon, when on or near the horizon, and when they appear largest, are actually four thousand miles further from you

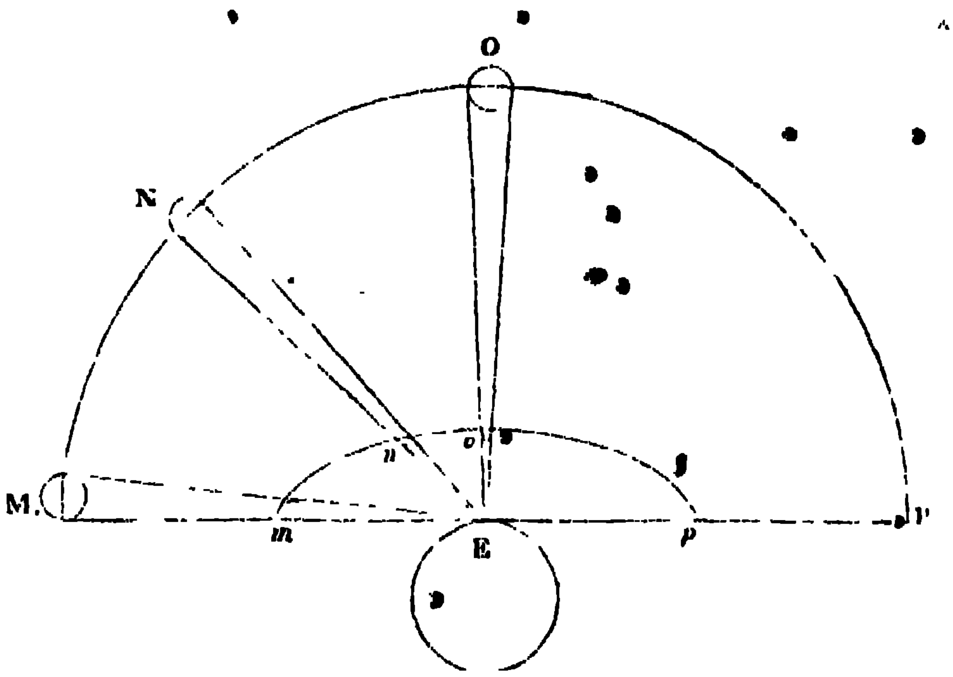
than when they are over your heads, or in the middle sky, or zenith, and appear the smallest!

5. Learn this, from the figure I subjoin. When the place B (as Bath or London) has the sun S in its zenith or meridian, the line running from the sun to that place is four thousand miles shorter (that is, a whole semi-diameter of the earth) than when the same place has come round to A, and has the sun in its horizon.



6. Astronomers, in the mean time, have thought it enough to say that the cause is this: The sky, as they observe, and as is represented in the next figure, does not appear to us as if it were (what it really is) the circular hemisphere M N O P, but like an oval vault only,

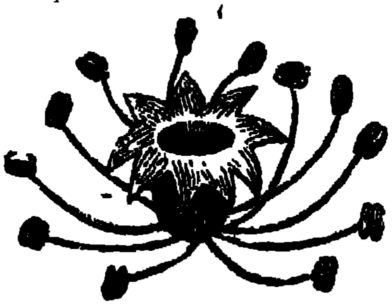
m n o p; and thus, the part at the zenith *o* seeming much nearer to the eye of the spectator at E, than the horizon at *m*, the sun seen in the horizon at *m* will be referred to a distance



E *m*, and have the apparent magnitude *m;* while the sun in the zenith will be referred to a distance E *o*, and have the apparent magnitude which is here drawn at *o*. But all this is insufficient, because the astronomers are still unable to tell us, why the zenith *o* appears nearer to the earth than the horizon M? In my preceding figure, I have shown you, that the *sun* or *moon* in the zenith are then really *nearer* to that spot upon the earth from which they are seen, than when they are on or near the horizon; but the puzzle that stops us is, that in the zenith they appear as if they were *further off!*

QUESTIONS.

1. Do the sun and moon appear to vary in their sizes, according as they are nearer or further off from the horizon or the zenith? 3. What is the horizon? 4. What is the zenith? Which is the middle sky? How many miles is half the diameter of the globe? How many miles really nearer to you, are the sun and moon when they are over your head, than when they are on the line of the horizon? 5. How does Parley show this by means of a diagram or figure? 6. What cause do some astronomers assign for the appearances in question? Do they say that the vault of heaven does not appear to us as a semicircular arch, but as a semi-oval, or as the half of an ellipsis? Does Parley's second diagram show the zenith and the horizon, and the difference between a true semi circular arch, and an arch that is elliptical?



CHAP. XXVI.

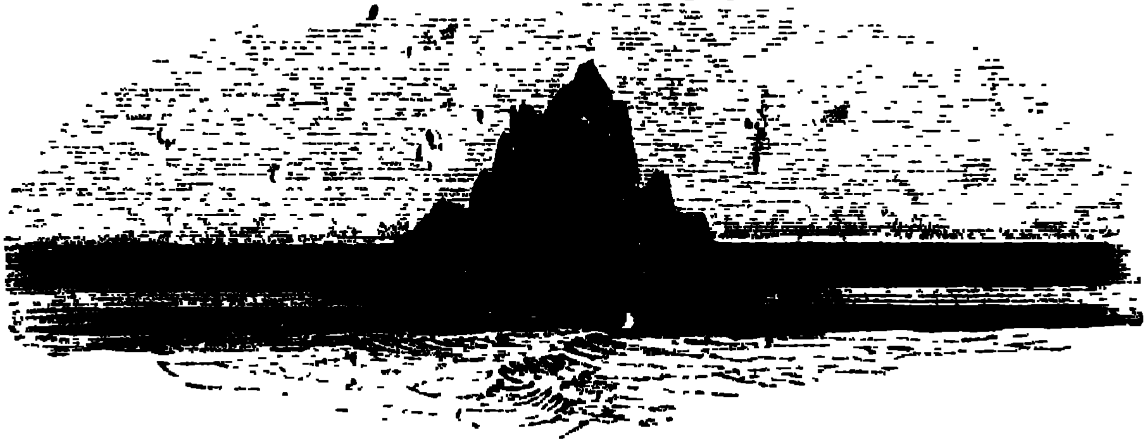
OTHER EXPLANATIONS.

1. AN explanation we find offered, why the sun and moon, when on or near the horizon, appear larger than when risen higher into the sky, consists in this; that while they are low in the heavens, or, as it were, near to the earth, we compare them, even without knowing that we do so, with the earth, and with the things upon the earth; and that while thus compared, they appear larger than when in the upper sky, in the void immensity of which there is nothing to be compared with them for size.

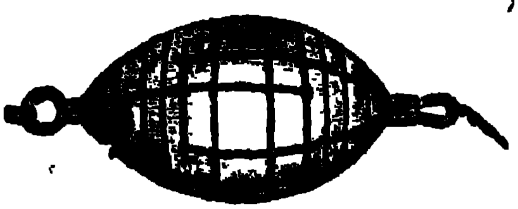
2. An astronomical writer suggests to us, that if we saw a man standing upon a rock in the middle of the sea, we might be enabled to think the rock a large object, through comparing the unknown size of the rock with the known size of the man; but that, if we see the rock without

the man, that is, with nothing to compare it

with but the vastness of the ocean, the same rock will seem considerably smaller; and this, he



says, is the case with a buoy, which, seen amid a breadth of sea, always appears much less than it really is.



3. He adds, that being himself at the inner top of the dome of St. Paul's, the variegated marble pavement underneath appeared to him to be no more than one-fifth of its real size; till, a man happening to walk over it, the comparison which his eye, immediately but involuntarily, made between the size of the man and the size of the pavement, the pavement as immediately appeared to increase in magnitude.

4. He relates, too, that, for the purpose of experiment, he has smoked a mirror, so that it should represent the vapours of the horizon; and that then, the moon in the zenith, thus reflected, both appeared ruddy, and also of increased size. Whereas, when the moon in the horizon was reflected up to the zenith by the mirror, its apparent size grew less.

5. The sun, or the moon, in the horizon, says another writer, appears larger than when higher up in the heaven. These bodies, in the horizon, are seen in the direction of many other objects, and therefore appear to be more distant; so that they are supposed to be larger than when more elevated. To destroy this illusion, roll a piece of paper into the form of a tube, and look through it at the sun or moon in the horizon, so as to see this *only*, and they will then appear no larger than if higher up in the heaven.

QUESTIONS.

1. What other explanations have been offered? 2. What about rocks at sea? What about a buoy at sea? 3. What about the dome and pavement of St. Paul's church in London? 4. What about the size and ruddy colour of the moon in the horizon? 5. What about an experiment with a roll of paper?

CHAP. XXVII.

PETER PARLEY'S HINT AT AN EXPLANATION. PARLEY EXTOLS THE ART OF DRAWING, AND THE SCIENCE OF PERSPECTIVE.

1. Let us sit down, then, my dear children, upon this bank, and admire the great and beautiful globe of the sun, while it is yet a

little above the horizon of that lake, and while we endeavour to figure to our understandings the cause why its magnitude appears to be every moment increasing.

2. I confess that I am dissatisfied with the explanations of which, in my preceding chapter, I have given you an account; but it is something, at any rate, to have made you acquainted with what has hitherto been said upon the subject by those who have most considered it, and what is usually repeated or received as entirely satisfactory.

3. To me, it seems that the question raised is to be answered only by reference to the principles of *perspective;* and, in reality, it was my first intention to draw a number of lines upon the piece of paper which I hold in my hand, in order to let you see my meaning. I perceive, however, that I should draw many more lines, and expend a great deal more time, than I had at first imagined, were I to proceed with my purpose; and that, besides, my whole explanation would grow too complicate, and require too

much previous knowledge of perspective in yourselves, to recommend my saying more upon the matter at our present opportunity. I will leave the sun, therefore, to increase in its apparent diameter, as, moment after moment, it is still descending; and as finally it seems to sink into the bosom of the lake before us. I am content with making use of this occasion for impressing upon your recollection the great value of that science of *perspective* which we have long talked of your beginning to learn. You are fond of drawing; and besides the many other inducements which are so obvious, for the pursuit of that beautiful and useful art, the *attention* which its practice compels us to pay to the forms, the colours, and to all the other visible distinctions of nature, is what makes it as contributive to the cultivation of our heads and our hearts, as to that of the ingenuity of our hands; but what is the success that we can hope for in the art of drawing, unaccompanied by a knowledge of *perspective?* What false, and what hideous drawing, do we not incessantly see, through the want of a knowledge of perspective in those who draw! To knowledge of perspective, also, we must frequently owe (as, I believe, in this instance of the varying apparent diameters of the sun and moon) a right understanding, as well as a right representation, of all the appearances of nature!

4. While we have been speaking, however, and while we have been looking at the last light of the sun, in the horizon above the lake, the very *Harvest Moon* of which I lately spoke to you has risen behind us, and has almost gained the zenith! Let us turn, then, from the lake, and enjoy, under the silver light of the moon, a landscape which at least rivals that of the lake; and which will make us full amends for our loss of the ruddy glories of the descending sun!

5. Here is a harvest-field, and beyond it are the mountains which bound this side of the valley. A loaded waggon is carrying homeward the sheaves that have been gathered upon the side of the field on which we see it. The

labourers are singing, as they accompany the creaking vehicle; and, after a night or two more, they will celebrate their harvest-home! At present, they are rejoicing in the lively scene which the moonlight falls upon around them.

6. But the moon, as I remarked to you, is already high in the heaven; and its apparent size is much less than when we behold it in the

horizon. Here recurs to us the question we were upon, though at the other end of the appearance to be explained. As the sun descended, we saw it increase in apparent diameter, and now, as the moon rises higher and higher, it seems to grow less and less; while by and by, descending in its own turn, it will seem, like the sun, to return to a greater diameter before it leave us. Beautiful and ministering orb! How it delights our eyes! how sweetly all things appear under its rays! how it softens, and (at the same time) how it enlivens our hearts! and in how many forms does it not contribute to sustenance and life over our globe! But I cannot, if even for its beauty only, believe in those ugly stories which so many tell us, about evil influences of the light of the moon! It must be the atmosphere, and not the moon, that is sometimes prejudicial to us at night!

7. But, hark! already, as we travel homewards, we hear the honest watch-dog at our neighbour's farm, baying the silver moon. The

attention paid to the moon by dogs has always been a subject of remark, and has even furnished ground for many practices and fables. Whether it be that the light of the moon renders the dog sleepless, and therefore more attentive than

usual to the smallest noise that can provoke his barking, or whether he really barks at, or bays, the moon itself, I think his barking (at a first thought so uncivil) one of the examples of his sagacity, or of the activity of his observing powers; and not a little allied, as to its motive, to the great attention which men themselves have always given to the moon. The dog does not bark at the sun; and it might sometimes seem as if even the human race, much as it thinks, and has always thought, of the sun, cherished, and has always cherished, yet deeper feelings in respect to the moon. But I attribute at least a great part of all this, to the varying and only occasional appearances of the moon. The sun comes daily, and is every day of the same figure; but the moon, both to men and dogs, comes, when it does come, as a stranger—a bright and lovely stranger; but yet a stranger, as the dog may think, to be watched, and even suspected, or which is at least a subject of perplexity and disquietude, so long as it remains in sight.

8. And since, too, the first writing and printing of my foregoing and other remarks in these chapters, as to the almost superior attention given by men, as well as by dogs, to the moon, rather than to the sun, from the cause I have assigned, and which superior attention, with

respect to men, amounts to something like a superior affection or regard, the subjoined Scottish anecdote, upon Scottish authority, has found a place in books.

9. "During the late annular eclipse, (the annular eclipse of 1836, to be presently described in my volume,) two old female worthies were heard discussing the merits of the two luminaries who were the principal performers on that occasion. Kirsty (who had all along been loud in praise of the moon,) at the time of the greatest phase, [the writer means the *darkest* appearance or phase] was in raptures at the thought of her favourite beating the sun; but her neighbour, Janet, not being so sure of the advantage, asked her, 'What way in a' the world hae ye cast out wi' the sun? My certie! I'm sure you're gay an muckle obliged to it, and it ill becomes you, or ony ither body, to say aught against sic an auld and faithfu' friend.' 'Oh, dear me! Janet, you're awfu' ignorant; o' what use has the sun been to either you or me? The moon gives us light in thae dark

Saturday eens, *but the sun never shines but when it's day-light.**' "

* Laird of Logan.

QUESTIONS.

2. Does Parley say that he is dissatisfied with all the explanations? 3. Does he say that he thinks the question belongs to the science of perspective? Does Parley very much recommend to his little hearers the study of perspective, and the practice of drawing? 6. Why does Parley, upon this occasion, contrast the rising of the moon with the setting of the sun? What does Parley say of the beauty and utility of the moon? 7. What of the baying of the moon by watch-dogs? What of the dog's not barking at the sun? 8. What of the great attention always given to the moon, both by dogs and men?

CHAP. XXVIII.

PARLEY TELLS ABOUT THE STARS.

1. AFTER telling you about the two great luminaries, the sun and moon, I shall talk of those lesser luminaries which next attract our attention; that is, of the general multitude of stars. It is in the same order that the whole are presented to us in the book of Genesis:—"And God," it is said, "made two great lights; the greater light to rule the day; and the lesser light to rule the night: *he made the stars also.*"

2. On the next page is a picture of some stars. You nightly see the stars. How pure and peaceful do they seem, as they twinkle far away in the clear blue sky! They appear very small, but recollect that they are at an immense distance. They are much further off than the moon; and though they seem smaller, they

are in fact a great deal larger than the moon. Some of them are millions of miles from us, and though they appear so little, in reality they are prodigious in their size.

3. Some of the stars appear larger and brighter than others. Some appear small, and are so faint as to be scarcely visible. Now those which appear largest are the nearest, and

those which appear the smallest, and most indistinct, are the furthest off.

4. It is more usual to talk of the solar system, and of the constellations into which the visible fixed stars are grouped, than to remember how many wonderful things have latterly come to be known concerning the fixed stars, star by star.

5. Many will seem to tell you, that we know so little about the fixed stars that it is scarcely worth while to talk of them; but, to say this, is not to keep pace with the progress of modern discovery. At present, we have an express branch of astronomy for the fixed stars, which we call *sidereal astronomy.* Still, it is true, that as compared with what we know of the planets, we know but little of the fixed stars.

6. It is to the two Herschels, father and son, that we are particularly indebted for our acquaintance with sidereal astronomy, or the especial science of the fixed stars. Less than a hundred years ago, even the little that we know at present had not yet been discovered.

7. I have room for only a very few words

about the fixed stars, but I wish you to know that there is much that may be learned.

QUESTIONS.

2. Are the stars larger or smaller than the moon? If they are larger, why do they appear to be smaller? What are the stars?

CHAP. XXIX.

ABOUT THE FIXED STARS. IN WHAT RESPECT THE FIXED STARS, SO CALLED, ARE REALLY FIXED. REAL AND APPARENT MOTION. VARIETY OF COLOUR. DISTANCES FROM THE EARTH. NUMBER. SMALL NUMBER OF STARS ORDINARILY SEEN WITH THE NAKED EYE.

1. THE fixed stars are so called, because, unlike the planets, they never "wander," or change their places among each other. Night and morning, age after age, they rise and set in the same order.

2. In any other respect, these stars are not to be called "fixed." Altogether they move around the earth in one grand and ceaseless procession, exclusive of that apparent motion which results only from the real motion of the earth.

3. An apparent annual motion of a fixed star in the circuit of the celestial sphere, if even amounting to no more than five seconds of a degree, has been computed, in the star 61 Cygni, to be really equal to one hundred and

twenty millions of millions of miles; "and yet," says M. Arago, "we call 61 Cygni a *fixed star*,—a fixed star he makes us observe, which is constantly *moving*, and moving at the rate of a hundred and twenty millions of millions of miles in the space of every year!

4. But this observation may mislead us, if we do not call immediately to mind the sense in which the *fixed* stars are said to be *fixed;* that is, as I have just now told it you above. Unlike the planets, they are fixed in their places as to each other. Suppose that you lay three books upon a table, you can easily turn round, and turn with considerable swiftness. Now mark the places where you lay the books, and measure their exact distances from each other; and see that the red book lies next the blue, and that the blue is followed by the green. Next, turn the table round and round, and turn it as swiftly as you will, but not with violence, so as to throw down the books. Well! stop the table; and though you will have seen tha the books went, as it were, all round the room,

while you were turning the table round upon which you had put them; and though, perhaps, when you stop, the *place of the books*, which was opposite to the fireplace when you began, is now opposite to the window; still, you find that *the books themselves* are upon the same place on the table, which you first gave them, and that they are at the same distances from each other, and that neither the red, the blue, nor the green has changed its place. These books, then, are *fixed books*, as respects their positions toward each other, and in respect of the table, let their motion altogether have been as extensive and as rapid as it might. Similar to this is the motion of the fixed stars in the circuit of the heaven; and it is in this manner that they are properly to be called fixed stars.

5. Or, permit me to compare this particular motion of the fixed stars, (for they have two or more motions,) with the motion of the sails and body of a windmill. The sails are driven round by the wind, and even the very body, or upper part of the body of the mill, is often turned round by the miller, that the sails may duly meet the wind. Still, both the body and the sails are a fixed body and fixed sails. All are fixed in their places, and move without departure from their places. Go round as rapidly as may happen, still the sails are fixed to their place on the mill, and to their distances from each other; and still the mill, though it may have been turned round, remains where it was; or still the upper part of the mill, however turned about, remains fixed to that lower part upon which it stood at first, and upon which it continues standing.

6. But, besides this general motion in space, and besides the revolutions on their axes, (like the sun and planets of the solar system,) some of the fixed stars are discovered to move round others that are near them.

7. Some of the lights in the heavens, which appear to our naked eyes to be single stars, are found, with the telescope, to consist in groups of two, and even of three, and still more stars; and in some of these cases, one or more of this group of stars are seen to move round a neighbour, after the manner of the planets round the sun.

8. All the fixed stars, too, may seem to you but as "silver stars," or of one colour. But they differ greatly from each other in colour, and exhibit among them such as are red, green, blue, and all the rest of the prismatic colours, and many of their mixtures.

9. Their distances from the earth are various, but all of them immense. The nearest fixed star has been reckoned at two hundred thousand times the distance of the sun.

10. As to the number of the fixed stars, those either discovered or discoverable by the telescope exceed any number that has yet been mentioned; it is millions of millions upon millions; while those commonly seen by the naked

eye are usually called a thousand, but by some are counted at little more than eight hundred; which small number of fixed stars, described as ordinarily visible in England with the naked eye, is thus summed up:

Of the first magnitude . . .	17
Of the second	79
Of the third	228
Of the fourth	510
	834

11. In different parts of the globe, different sets of the stars are visible, but always in comparatively small numbers to the naked eye. But how vast the numbers to the telescopic vision! Recollect, too, with the accounts of their numbers, that each particular fixed star is believed to be a sun to a system of planets, like the sun of our own system; and then what can it be possible to say sufficient, either of the multitude of the heavenly bodies, or of the immensity of space?

CHAP. XXX.

MAGNITUDE OF THE FIXED STARS. AMAZING MAGNITUDE OF THE GREAT STAR VEGA. CLUSTERS OF STARS.

1. BUT, if the fixed stars resemble our own sun or star in being surrounded by planets, our sun, and consequently its planets, bear little resemblance, in point of magnitude, to the fixed stars, and consequently to their planets. The sun and all its planets dwindle into comparative atoms, at a view of the fixed stars, if the modern astronomers, with their modern telescopes, can entirely be trusted. We are assured (for example) that the star *α*, in the constellation Lyra, of which the distance from the earth is twenty billions of miles, has a diameter of 2,659,000,000 miles, or three thousand times that of the sun, or the same as three-fourths of the diameter of the whole solar system, the orbits of the comets excluded; that is, three-fourths of the orbit of the planet Uranus, called otherwise Herschel and the Georgium Sidus!

2. This, in general terms, is to say, that the magnitude of the star Vega, or α Lyræ, surpasses that of the sun, more than the magnitude of the sun surpasses that of Mercury; or, that the disproportion between that star and the sun is perhaps *three times as great* as that between the earth and Jupiter; for a display of which latter disproportion you must consult a future page.

3. But, again, you will hear, in another chapter, that at the surface of the sun, a man would weigh two hundred tons. What, then, would he weigh at the surface of the star Vega? Tell me how many thousand tons?

4. I told you, in my chapter about the sun, or the star of our own system, that, great star as it is, in comparison with our planet the earth, and with all the planets put together, still it is a very small star, as compared with the stars in general; and see, now, though very imperfectly, in such a figure as that at my page 178, what it is to say, that the size or magnitude of the sun, supposing it such as it is there drawn, is sur-

passed by that of the star α Lyræ, by three-fourths as much as our orbit of Uranus (the very outermost of our white circles) surpasses our drawing of the sun!

5. The determination of the diameter of α Lyræ is due to a distinguished English astronomer.* An objection, indeed, under the Newtonian theory of light, has been started, to the possibility of its accuracy; "but, however this may be," (says a still later astronomical authority, while adverting both to the magnitudes and distances now assigned to the fixed stars,) "it cannot be doubted that the scale cannot be greatly different."†.

6. Many clusters of stars appear like white clouds, or like comets without tails. They suggest the idea of globular spaces in the heavens, filled full of stars, and constituting a society of stars apart from all the rest. To attempt to count the stars in one of these globular clusters, says Sir John Herschel, would

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* The late Dr. Brinkley, Lord Bishop of Cloyne.

† Quarterly Review, vol. xxxviii. p. 9.

be a vain task. They are not to be reckoned by hundreds. Many must contain from ten to twenty thousand stars, within a space of no more apparent diameter than the tenth part

of that which we see occupied by the moon; but of which the centre, where the stars are thickest, is one blaze of light.

7. And these luminous bodies—every white speck which you see in my figure—must be a sun, or a group of suns; that is, bodies shining

with their own light: for if they had only reflected light, their distance is so great that we should not see it at all; that is, that we should know nothing of their existence!

8. But, if they really are suns, and if their real distances each from each, are as great as the distance of the sun of our system from the nearest fixed star, or nearest sun of another system, what must be the real magnitude of this cluster before you; and what, again, the greatness of its distance from ourselves, on account of which the whole of the gorgeous assemblage is but barely visible to our naked eyes?

9. The figure upon the right is one of those dashes of light, or spindle-shaped *nebules*, which belong to another class of objects that still further enrich the heavens, and of which I shall speak in another chapter. Sir John Herschel has added a list of five hundred nebules to that of the two thousand discovered by his father.

10. The double stars are of various hues; but usually the colour (like the magnitude) of any one star, is in contrast with the colour of the

other. The large star is generally yellow, orange, or red; and the small star blue, purple, or green. Sometimes one of the stars is white, and the other blue or purple; and sometimes, though more rarely, one is red, and the other white. Many solitary stars are red; but none blue, green, or purple.

11. You are to remember, in the meantime, that it is only as these points of coloured light, that the largest of the fixed stars display themselves, even in the view of the most powerful telescopes. They show but dots of light, and have no apparent discs, like those figured circles which I shall present you with in telling of the planets.

CHAP. XXXI.

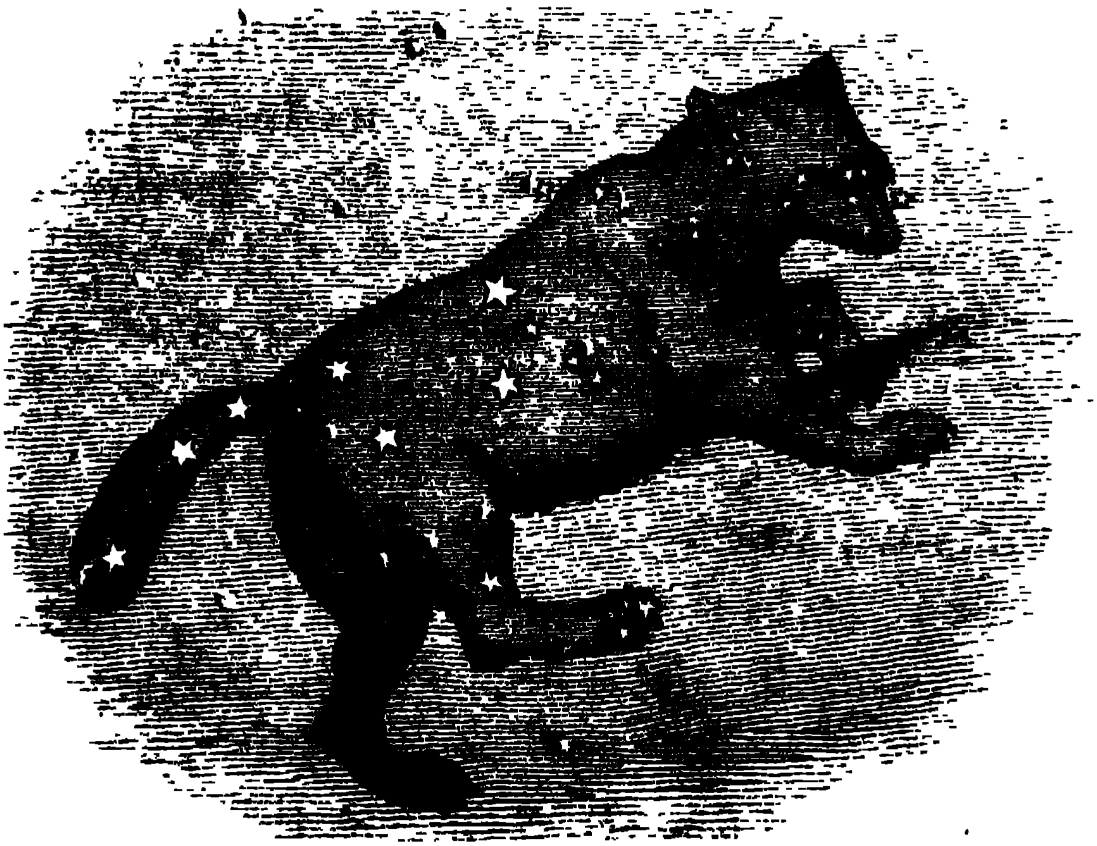
ABOUT THE CONSTELLATIONS.

1. When we look up to the heaven or sky, it seems as if the earth were surrounded by a vast hollow sphere or globe, sprinkled over with stars. Now let us imagine that the heaven is such a hollow sphere. Let us imagine, that the sphere has an equator passing from east to west around the middle of it. Let us imagine, that it has two poles, like the earth; and that the North star, which may be seen in the sky, is the North pole.

2. Now, in the centre of this great hollow sphere is the sun; and the planets are all moving round the sun, within this sphere, from west to east.

3. I must now tell you one thing further; that the ancient astronomers divided the fixed stars into various groups, to all of which they gave particular names. A collection or group

of stars, they called (what the word signifies) a constellation. In one constellation, or collection or group of stars, they fancied they could discover something like the form of a Bear, and therefore they called it the Constellation of the Bear.



4. Another constellation they fancied resembled a Lion, another a Goat, another a Serpent;

and so they gave these constellations the names of the animals they were imagined to resemble.

5. The picture on the opposite page is an illustration of what I have been telling you. It exhibits a group which is to be seen in the Northern part of the heaven, and is called Ursa Major, or the Great Bear.

6. In this manner, the stars of the whole heaven are divided into groups or constellations. Upon the surface of a celestial globe, you see all the figures of all these living creatures, with those of a few other objects, marked upon it, the forms of which were imagined to be represented by the various groups; or which forms, rather, they chose to assign to these groups, bestowing also the names.

7. It has been well suggested, that the names and forms of *living creatures* were those usually assigned to the stars and constellations, in order to imply that they were *moving things*, or bodies always moving in their celestial regions. It is in this manner that Chandra, or the Moon, is figured by the

Hindoos as if it were an Antelope. The antelope is, perhaps, the swiftest of animals; and of the swift motion of the moon I have told you, in my account of the eclipses both of the moon and sun.

QUESTIONS.

1. What do we see when we look up to the heaven or sky? 2. If we imagine the heaven to be a hollow sphere, what is in the centre of that sphere? What are moving around the sun within that sphere from west to east? 3. What did the ancient astronomers do? What did they call a collection of stars? 4. Why did they give the names of animals to the constellations? 6. What are the stars of the whole heaven divided into? 7. Why did the ancients usually assign to the stars and constellations the names and forms of living creatures?

CHAP. XXXII.

ABOUT NEBULES. COMMON NEBULES. STELLAR NEBULES. PLANETARY NEBULES.

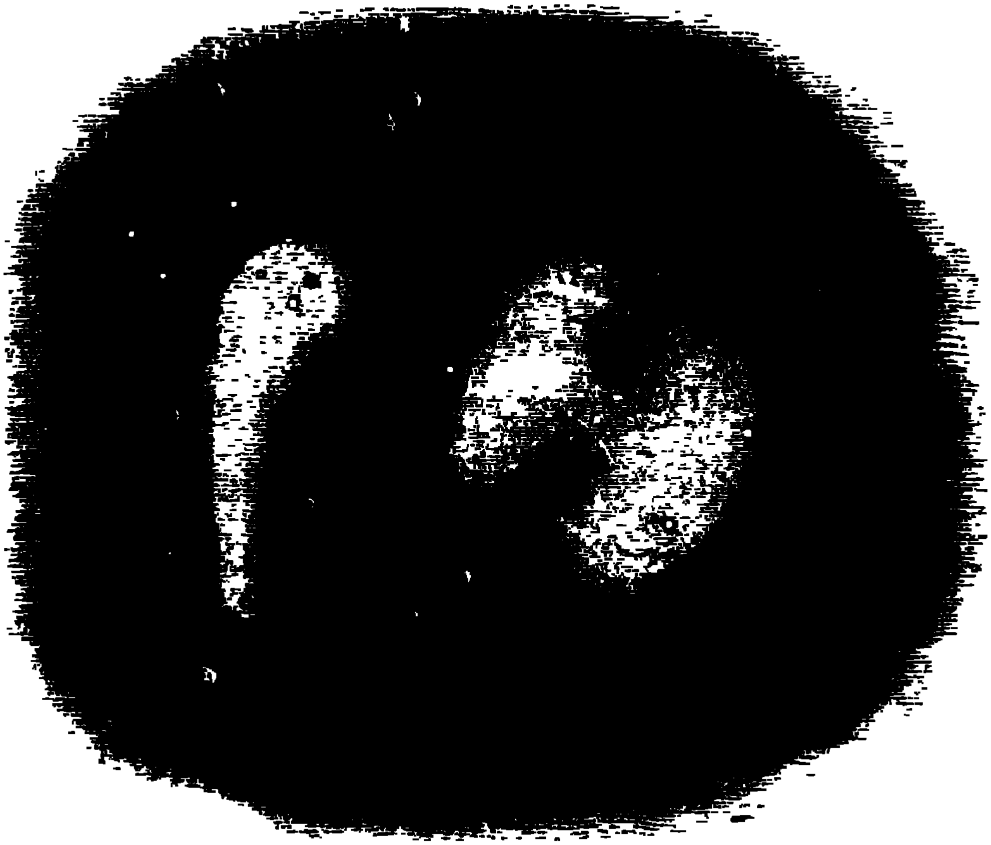
1. And it is not even at the visible fixed stars that we can stop. When the heavens are examined with a good telescope, the same appearance, with respect to the distribution of the stars, is still observed, as when they are seen by the naked eye. In some places the stars are close and in great numbers; and in others there are large voids without a single star.

2. But, in those voids, as well as *behind* the remotest stars that we can discover, there are numbers of small luminous spots, of a cloudy appearance, which we thence call *nebulæ* or *nebules.*

3. Some of the larger nebules are accompanied by smaller. Some, in shape, are long and narrow and bright dashes; others, like the electric spark, have the shape of a fan. Others

resemble comets, or are like cloudy stars, having a nucleus or centre, surrounded by a nebulous or cloudy atmosphere.

4. Accompanying the cluster of stars in a preceding chapter, you saw a nebule of a spindle shape, or like a light dash upon the face of the dark heaven. Above are two figures of nebules of other forms; that upon the right hand bearing some resemblance to a



dumb-bell, or to an hour-glass, of bright matter, immersed in a thin hazy atmosphere, by means of which an oval form, or that of an oblate spheroïd, is given to the whole mass. This is one of the most amazing objects in the heavens, of the class of nebules. Three stars are apparent within its circumference, and one adjacent to it. Its light is perfectly milky.

5. Besides nebules in general, Sir John Herschel distinguishes stellar or star-like nebules, and planetary or planet-like nebules; and he makes even these latter of enormous dimensions. Supposing them even no further from us than the fixed stars, he computes, that at the lowest estimation, their real magnitudes must be such as to cause each of them to fill a space equal to that of the orbit of Uranus, or the whole of the solar planetary system! Such a magnitude, however, for nebules, is insignificant, compared with the same magnitude for the single star Vega, or *α* Lyræ!

6. But the term *nebula*, or *nebule*, has been used in more senses than even the two I have

just mentioned, since the time when, in the seventeenth century, Cassini called the Nebule of the Sun, his supposed matter of that appearance which is at present called the Zodiacal Light. I shall tell you about the Zodiacal Light, in one of my ensuing chapters.

CHAP. XXXIII.

ABOUT THE MILKY WAY, CALLED BY SIR WILLIAM HERSCHEL THE PROJECTION OF THE NEBULE OF THE EARTH. ABOUT AN ASTRONOMICAL DISTRIBUTION OF THE REGIONS OF THE HEAVEN. THE MILKY WAY SOMETIMES CALLED SAINT-JAMES'S WAY.

1. SIR William Herschel set down the positions of no fewer than two thousand nebules; and, in a small portion only of the Milky Way, he counted fifty thousand distinct stars, and thought he saw indistinctly twice as many more.

2. The Milky Way is the white or milk-like band which stretches across the sky from east to west, and the whiteness of which is found to consist in the light of the myriads, not to say

the millions, of stars which are thus assembled in it. The Milky Way is sometimes called Saint-James's Way.

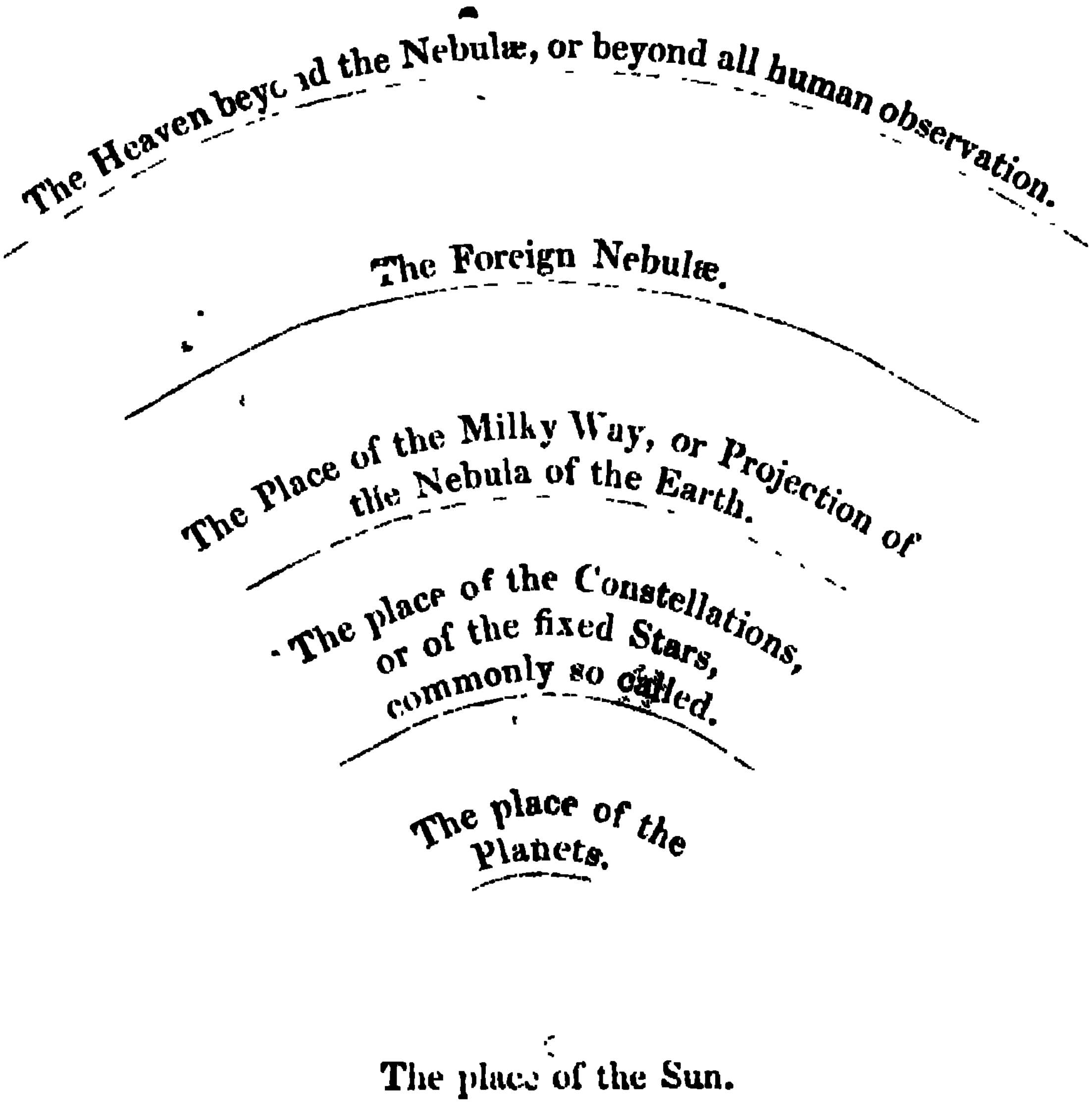
3. Sir William believed the Milky Way to be the projection of the nebule which contains the earth, the solar system, and all the fixed stars of which we commonly speak; thus placing the Milky Way at a still greater distance from us than the most distant of the fixed stars!

4. The thickness of the Milky May is small, compared with its length and breadth. Sir William Herschel believed the earth to be fixed about midway between the inner and outer surfaces of the Milky Way, near the point at which it spreads into two branches.

5. As to the nebules beyond the Milky Way, many (whether truly or otherwise) are at present generally believed to consist, not in clusters of stars, but only of a self-luminous phosphorescent substance, in a high state of rarefaction, or composing only a milky film.

6. When it is remembered, however, that many of the acknowledged clusters of stars

(and the Milky Way among the rest) "appear to unassisted vision like thin white clouds or vapour," and are compared with "milky films," is there no hastiness in absolutely denying, that even these distant milk-like clouds of nebules may be yet starry clusters also?


The Heaven beyond the Nebulæ, or beyond all human observation.
The Foreign Nebulæ.
The Place of the Milky Way, or Projection of the Nebula of the Earth.
The place of the Constellations, or of the fixed Stars, commonly so called.
The place of the Planets.
The place of the Sun.

7. But, decide that question as we may, the several regions of the heaven, as they depart from the earth, appear susceptible of astronomical arrangement, as in the opposite diagram.*

8. In allusion to the famous Roman, or Roman-British road, called Watling Street, which, beginning in London, runs so far throughout the kingdom, an old English poet has called the Milky Way, "the Watling Street of the sky."

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* For a fuller explanation of this diagram, accounts of the nebules, and various other astronomical and general information, see "Burford Cottage and its Robin Redbreast; a Village Tale. By the Author of Keeper's Travels."

CHAP. XXXIV.

PARLEY TELLS ABOUT THE SOLAR SYSTEM, OR SYSTEM OF THE SUN.

1. I HAVE led you on, my little ones, from the moon to the sun; from the sun, to the distinct and visible stars, (visible either to the naked eye, or through the magnifying power of the telescope,) including the multitude of stars which make up the whiteness of the Milky Way; and then I have told you of the Nebules in the still further heaven, which are clouds of more distant stars, or what some have called clouds of *star-dust;*—Nebules, in the midst of some of which stars are still partially distinguishable; but which, for the most part, some consider but as so many white vapours, like the white and little clouds in a summer's sky; and believe to consist only in a filmy milk-like matter:—Nebules, however, which still keep their forms and

their places in the celestial space, and do not vanish, or even visibly move, like the white clouds in our blue skies.

2. I have told you next, that in the opinion of Sir William Herschel and others, the Milky Way is but the projection or visible boundary of the Nebule of the Earth, or of a cloud of stars which comprehends, not only the Earth, but the Sun, and the whole System of the Sun, or the whole Solar System; and not only the whole Solar System, but the whole of the Fixed Stars, or those stars which we can distinguish one from another, instead of losing them in cloudy vapour-looking clusters.

3. I have told you, also, that we might call this Nebule of the Earth, the Nebule of the Sun, or of the Solar System; and further, that the name of Nebule of the Sun was used by Cassini to signify a very different object; namely, a circular body of luminous matter which moves about the sun in the same manner as the planets, or which surrounds it like their imaginary orbits.

4. After rising, therefore, from the comparison of a balloon, to that single and familiar celestial body which lights us by night, and which we suppose to be, at least ordinarily, the nearest of all the celestial bodies to the earth; I have led you, in imagination and in knowledge, first to the sun, and then amidst the millions upon millions of the remoter celestial bodies, and to the remotest bounds of discovered space; and I now come back from the further or Foreign Nebules, to the Nebule of the Earth, or of the Solar System, which is our own, and of which the Solar System, though a minute part, is still the part of liveliest interest to ourselves, and the most within reach of our discoveries. Let us talk, now, therefore, of the Solar System.

5. *Sol* is the Latin word for the sun; and, from the Latin word *sol*, we have the English word *solar*, by means of which we denote whatever *belongs to the sun.*

6. But the Solar System is an assemblage of celestial bodies, including the earth; all dependant upon the sun, all moving round the

sun, all keeping for ever near it; and therefore all *belonging to it.*

7. Now, in one sense, the celestial bodies which belong to the sun are a single assemblage of *planets.* For, by the term *planets* is meant *planetary stars;* or, *moving* stars, or *moving* luminous celestial bodies. It is thus that Planets are distinguished from Fixed Stars.

8. But these planetary, or moving bodies, which belong to the sun, are, in the first place, of two kinds; that is, some are what we commonly call Planets, and others what we commonly call Comets.

9. Further, the bodies which we commonly call Planets, are also of two kinds; for some are Primary Planets, or planets which simply move around the sun; and others are Secondary Planets, or planets which (like the moon around the earth) move around the Primary Planets to which they belong; and only move round the sun as in attendance upon the Primary Planets; like little boats that are drawn after great ships.

10. Because the Earth is sometimes called the World, and because the World is sometimes called the Universe; therefore the Solar System is sometimes called the System of the World, and sometimes even the System of the Universe.

11. To speak of the Solar System as the System of the World, (that is, of the earth,) may seem excusable, because, to us, the Earth or World is its most interesting part; but the origin of that mode of speech, as well as of the phrase, the System of the Universe, is doubtless to be traced to the time when the Earth was regarded as the centre of the Universe, and even as the Universe itself; with the sun, moon, and stars to move round it, and to attend upon it.

12. But because, in the view of later astronomy, the Solar System is a system or assemblage of planets (the Earth being one) which compose the *system*, the sun being its centre; therefore this *system* is sometimes called the Planetary System, rather than the Solar System.

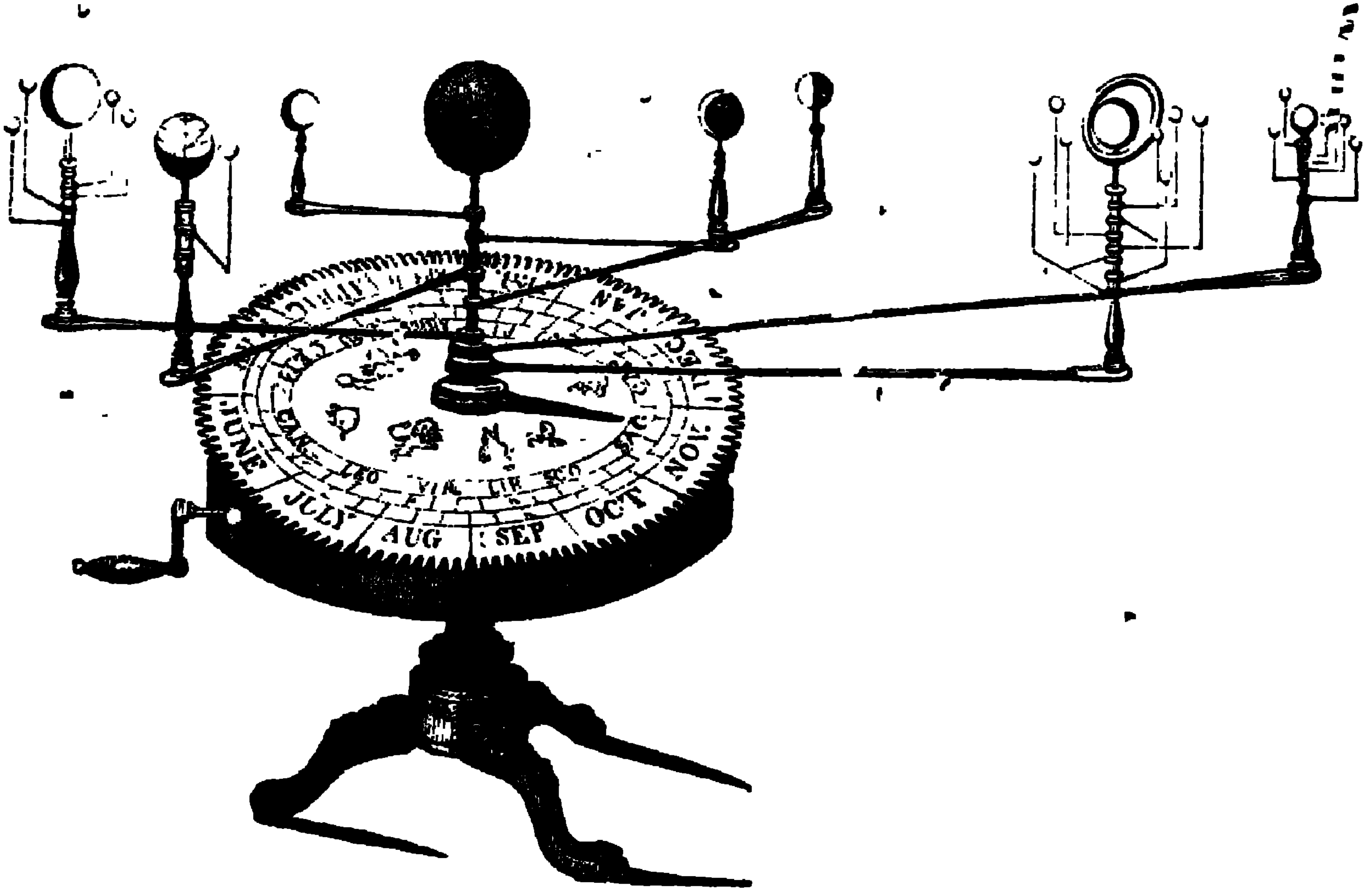
CHAP. XXXV.

ABOUT AN ORRERY OR PLANETARIUM.

1. From the same reference to the planets, more immediately than to the sun, the philosophical machine of which I am going to show you a picture, (and of which the design is to exhibit the several bodies, and the movements of the bodies, belonging to the Solar System, or the Planetary System,) is sometimes called a Planetarium, as it is also sometimes called an Orrery.

2. On the upper plate of this Orrery or Planetarium (which answers to the ecliptic) are placed, in two opposite but corresponding circles, the days of the month, and the signs of the ecliptic, with their respective characters. By this plate we may set the planetary balls so as to be in their respective places on the ecliptic for any day in the year.

3. You perceive that through the centre of


JAN
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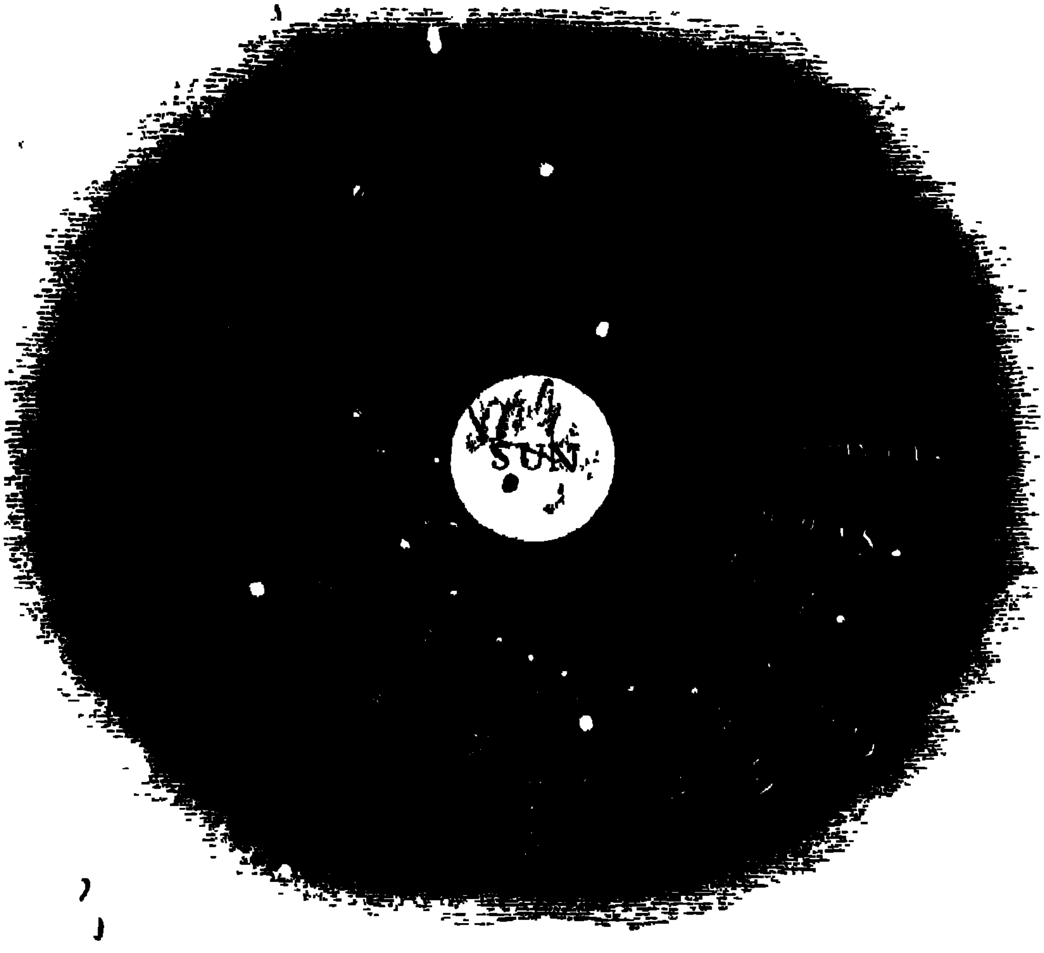
the plate a strong brass stem passes, on which is a brass ball, to represent the sun, and that round the stem are different sockets, to carry the arms by which the several planets are supported.

4. The planets themselves are represented by ivory balls, having the hemispheres which are towards the sun white, and the other black, to exhibit their respective phases. These are movable, and may be taken off or put on as occasion may require. About the primary planets are placed the secondary planets or moons; and the motion, requisite to produce the various phenomena of the appearance of the whole, is effected by turning the handle, which communicates with a train of wheelwork, concealed in the circular brass box under the upper plate. A small lamp, instead of the ball, is sometimes placed on the centre stem; and this has a pleasing and instructive effect, because it actually enlightens the part of each planet that is turned in its direction.

CHAP. XXXVI.

ABOUT THE PRIMARY PLANETS. ABOUT ASTEROIDS.

1. BUT, from the machine and model called a Planetarium, let us now turn to the planets



themselves. Here is a picture of the sun, as surrounded by its several primary planets. These are now to be reckoned twelve in number. You will perceive that the names of eleven are Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Herschel; and those of the four smaller planets, Vesta, Juno, Pallas, and Ceres; to which is to be added a fifth new and minute planet or asteroïd, discovered at the latter end of the year 1836, by the Italian astronomer Cacciatore.

2. They are all great bodies, but some are bigger than others. The five last are smaller than the rest, and are sometimes called asteroïds; which latter word means bodies that are only planet-*like* or star-*like*. Planets and stars are often equally called "stars."

3. Now these twelve planets, or seven planets and five asteroïds, are at different distances from the sun. They are all at immense distances, the nearest being thirty-seven millions of miles from the sun, while the furthest is eighteen hundred millions of miles.

4. It is difficult, if not impossible, to form

any conception of such vast distances. The earth is eighty-two millions of miles from the sun. Now, the wood-pigeon is one of the swiftest birds that flies, and it will fly about two miles in a minute. Yet it would take a pigeon, were it to fly with its utmost speed, night and day, at least one hundred years, to go from the earth to the sun.

5. You will bear in mind, that some of the planets belonging to the Solar System are visible to the naked eye, and that some are not. All the seven primary and larger planets may be seen on a clear night. One of the asteroïds, or lesser though still primary planets, may also sometimes be seen. All these bodies are continually changing their places in the sky. At one time, Jupiter may be seen at one part of the heaven; a few weeks after, it will be seen in another part; and the same may be said of all the other bodies (the Earth and the Comets inclusive) which belong to the Solar System. It is this which distinguishes the *planets* from *stars*, both in name, and as they are seen and

watched in the heavens; and causes them to be called planets.

QUESTIONS.

1. What are the names of the seven planets? 2. What of the five asteroïds? What is the meaning of the word asteroïd? 3. How far is the nearest planet from the sun? How far is the most distant planet? 4. How far is the earth from the sun? How long would it take a pigeon, even if it could fly constantly, to fly from the earth to the sun? 5. Are all the bodies belonging to the solar system visible to the naked eye? Which of them are visible on a clear night? Are the planets always in the same place? What of Jupiter? Why are the planets so called?

CHAP. XXXVII.

PARLEY TELLS ABOUT MERCURY.

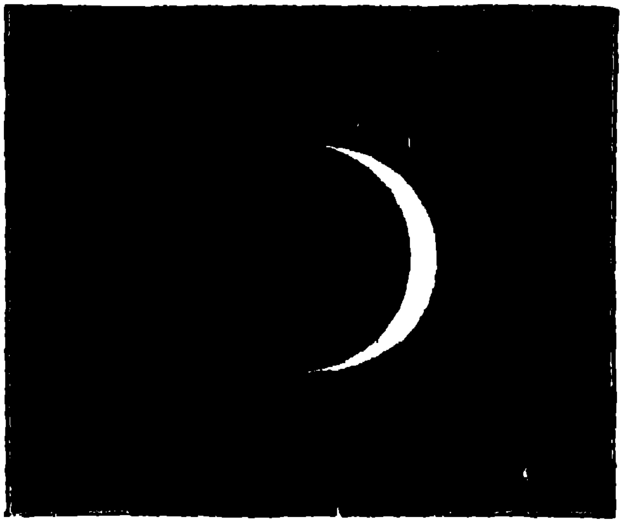
1. I WILL now tell you about Mercury. This is the nearest of all the planets to the sun; yet it is thirty-six, or thirty-seven, millions of miles from the sun.

2. It revolves round the sun once in about three months, and turns on its own axis once in about twenty-four hours. It is seldom seen with the naked eye; but, observed through a telescope, it exhibits nearly the same phases as the moon. That is, sometimes it appears to be round, and sometimes but partly round. These various appearances are to be accounted for in the same way as the various appearances of the moon.

3. Mercury is the smallest of the seven larger planets. It travels round the sun at the rate of one hundred and ten thousand miles an hour. Being the nearest planet to the sun, its light is exceedingly brilliant; and its body and atmo-

sphere are imagined to be seven times as hot as on the earth. It is said, that if there were water there, it would be immediately converted into steam; and that lead and tin, if such things are there, must be always in a melted state.

4. It is because of its nearness to the sun, that we can comparatively seldom see the planet Mercury. It travels with the sun, and is visible for not more than two hours before the rising of the latter, and for not more than two hours after its setting. For all the rest of the time that the sun is above the horizon, the planet is lost in the splendour of its rays.

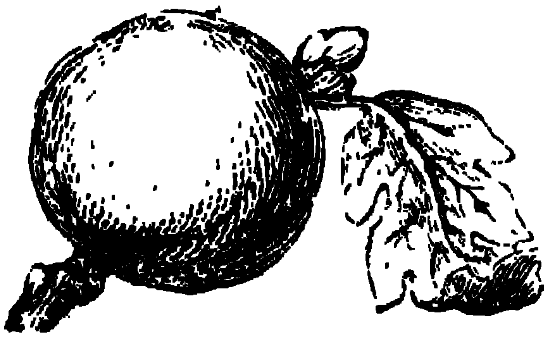


5. Examined through the telescope, Mercury

appears of an emerald-greenish colour; but as it changes like the moon, it is rarely seen a perfect round. The crescent-shape shown in the engraving is one among its several appearances or phases.

QUESTIONS.

1. Which is the nearest planet to the sun? How far is Mercury from the sun? 2. How long is it revolving round the sun? How long does it take to turn round on its axis? How does Mercury appear through a telescope? How are its various appearances to be accounted for? 3. Which is the smallest of all the planets? How many miles does Mercury travel in an hour? What of its light and heat? How would water, lead, and tin, be affected, as it is sometimes thought, by the heat, in the planet Mercury?



CHAP. XXXVIII.

ABOUT VENUS.

1. Venus is further from the sun than Mercury, and nearer than the earth. It is about sixty-eight millions of miles from the sun. It is a little smaller than the earth. It turns on its axis in about twenty-four hours, and consequently its days and nights are about as long as ours. It revolves round the sun in seven months and a half; therefore, its year is not quite two-thirds as long as ours. It travels in its orbit at the rate of seventy-six thousand miles an hour. It is supposed to be almost twice as light, and twice as hot, in Venus, during its summer, as upon the earth at the same season; and the winter in Venus is twice as cold.

2. Sometimes this beautiful planet is seen in the east, before the sun rises; and it is then called "the morning star." Sometimes it is seen in the west, after the sun is set; and it is then called "the evening star." I dare say you have

looked at it very often. Its light is very white, and I think it the most beautiful of all the planets. It appears larger than any other; but this is partly because it is the nearest, and partly because it is so bright.

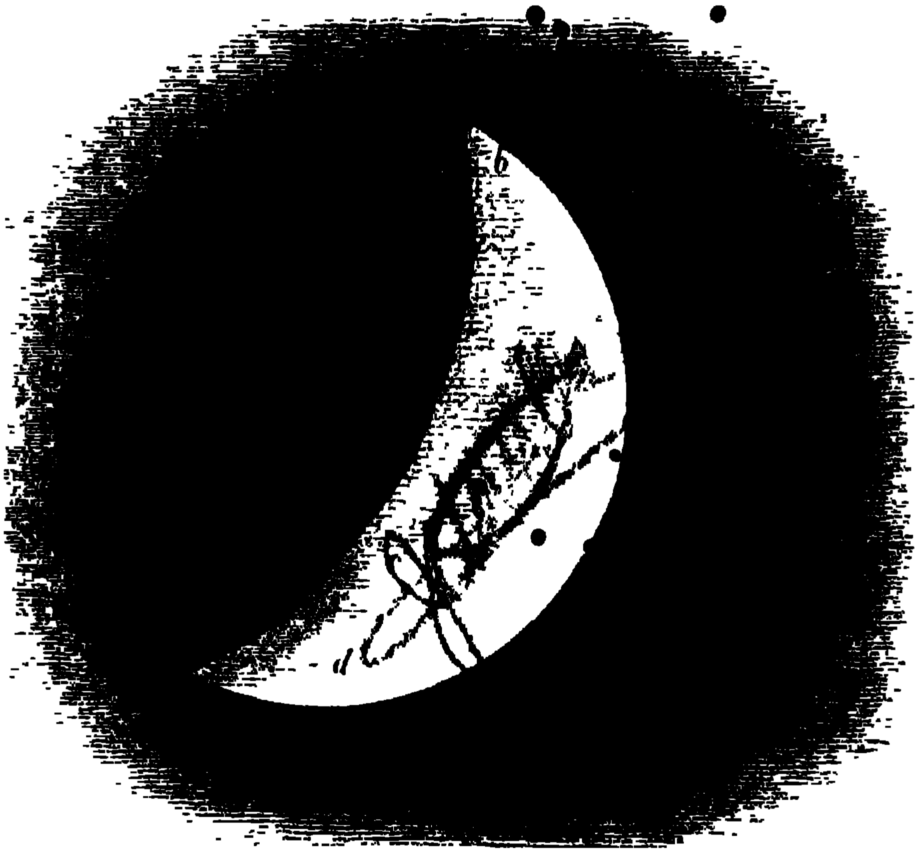
3. Sir John Herschel relates, that in the climate of the Cape of Good Hope, Venus shines so brightly, that the most minute parts of objects, such as the leaves of trees, are perfectly well distinguished by its light; and this not only by contrast, (as when such leaves are seen against a white wall,) but even when lying upon the ground.

4. The light afforded by Venus is in every country found remarkable, so that this planet has always arrested great attention. Its brightness, its successive phases, and its magnitude, seem to have conspired to make it regarded as a sort of smaller but yet second moon. Even in our northern skies, Venus is so very brilliant as to be sometimes seen by daylight.

5. But the greatest apparent brightness of Venus is discovered periodically. This is at

intervals of eight years, or when (the Earth's atmosphere being at the same time transparent) Venus is in its highest north latitude.

6. Sometimes, though very seldom, the disc of Venus is variegated with darkish spots. On the 19th of June, 1780, Sir William Herschel saw the spots represented in this figure; where



d c is a darkish blue spot, and *c e b* a lighter spot. He supposes the spots to be parts of the real surface of the planet, seen through openings in its atmosphere; and that the great density and uniformity of the atmosphere of Venus are the causes why the spots are rarely seen.

7. The surface of Venus, like that of the moon, is very mountainous; but certain astronomers are supposed to have estimated even the highest of its mountains at an extravagant height. According to Schröter, they are still higher than those of the moon; and there is one which surpasses Chimborazo, in South America, by twenty-four thousand feet! The whole height of Chimborazo is less than twenty-two thousand!

QUESTIONS.

1. Where is Venus? How far is it from the sun? How large is it? How long is it turning on its axis? How long revolving round the sun? At what rate does Venus travel round the sun? 2. When is it called the morning star? When the evening star? Why does it appear larger than the other planets?

CHAP. XXXIX.

ABOUT THE EARTH. ABOUT THE ARMILLARY SPHERE.

1. THE next planet to Venus is the earth. It is eighty-two millions of miles from the sun, and travels round him in three hundred and sixty-five days, five hours, and forty-nine minutes. The earth has a diurnal motion, by which the inhabitants at the equator are carried at the rate of one thousand and forty-two miles in an hour. The surface of the earth contains in all about one hundred and sixty millions five hundred and twenty-two thousand and twenty-six square miles; nearly three-fourths of which are covered with water. I shall tell you much more about the earth hereafter.

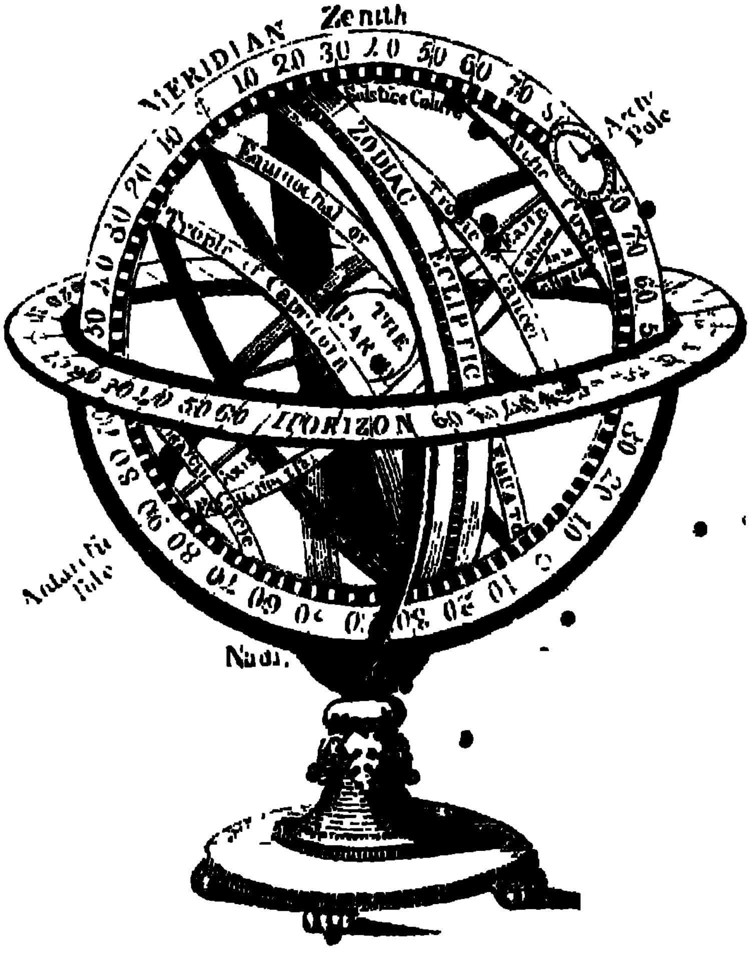
2. The earth, by its revolution about the sun in three hundred and sixty-five days, five hours, and forty-nine minutes, measures out that space of time which we call a year; and the line described by this annual revolution about the

sun is called the ecliptic. This line is always laid down on the artificial globes, divided into twelve distinct portions, each containing thirty degrees, and marked with the twelve signs of the zodiac.

3. The ecliptic, which, as you have before seen reason to understand, is an imaginary line, drawn through the middle of the equally imaginary belt of the zodiac, is represented, and marked with its degrees, in my figure of an Armillary Sphere; where, also, you see the earth, and the various other imaginary circles and points (as those of the tropics, the meridian, and the zenith and nadir) which astronomers and geographers describe about it, in order to assist our knowledge of its phenomena.

4. The armillary sphere revolves upon an axis within a silvered horizon, which is divided into degrees, and movable every way upon a brass supporter. In Pembroke Hall, Cambridge, there is an armillary sphere constructed by Dr. Long, which is eighteen feet in diameter, and

will contain more than thirty persons sitting within it, to view, as from a centre, the representation of the celestial spheres.

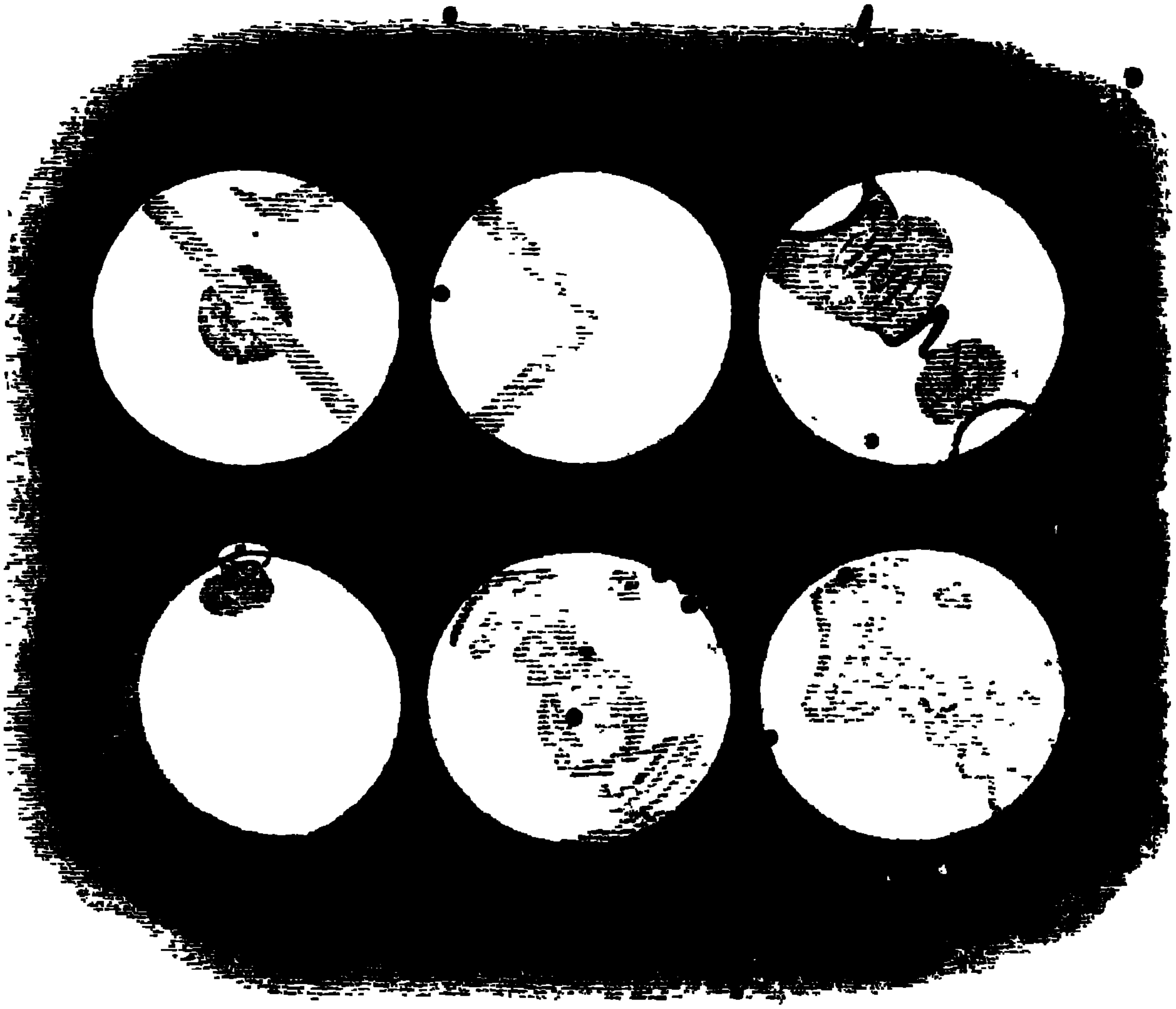


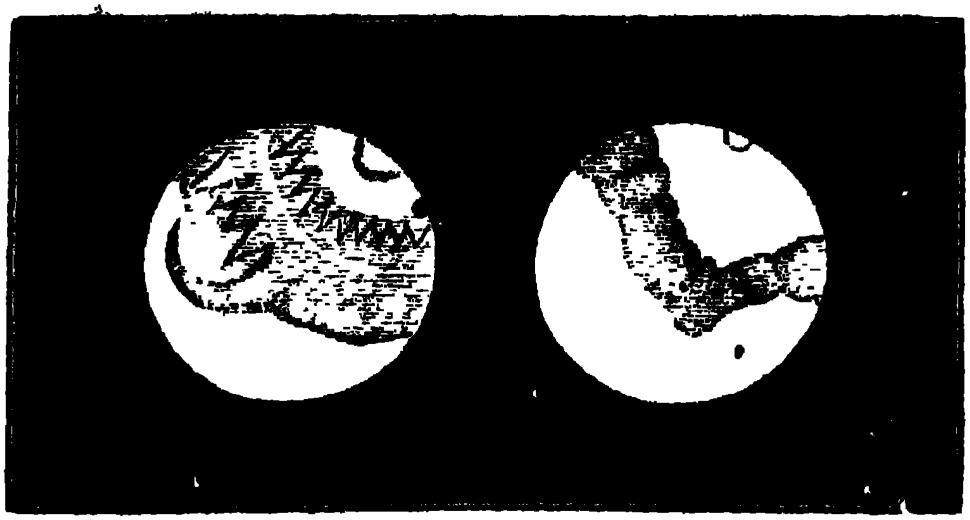
CHAP. XL.

ABOUT MARS.

1. Mars is one hundred and forty-four millions of miles from the sun. It turns round on its axis once in twenty-five hours. Of course, its days and nights are a little longer than ours. It revolves round the sun once in about two years. It travels in its orbit at the rate of fifty-five thousand miles an hour. It is supposed to be much darker, and twice as cold, in this planet, than on the earth. Mars may be seen with the naked eye. It is of a remarkably red colour. When observed through a telescope, sometimes very singular figures appear upon it.

2. The first and second of these round pictures show you appearances observed upon the disc of Mars in the year 1719, when that planet was in opposition to the sun, and looked superior to Jupiter in brightness and magnitude. A long belt, as you have seen, extended half way round

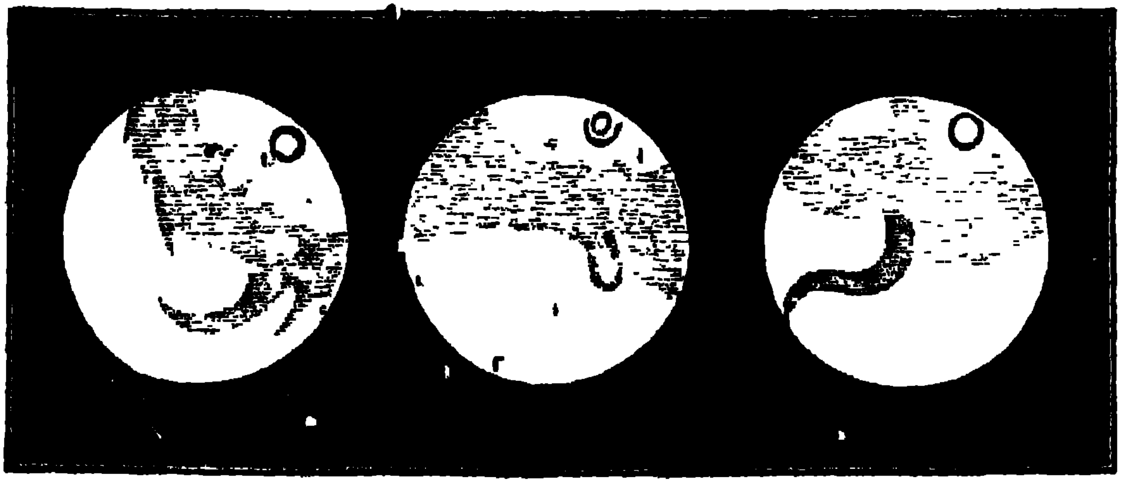




the planet, and was joined by a shorter belt, forming together an obtuse angle.

3. The remainder of these pictures, and the three that follow, complete all the permanent and equatorial appearances of the planet, as they are seen to follow each other in immediate succession, while the planet, in the revolution of its day of twenty-five hours, turns upon its axis.

4. The very luminous ring-like appearance, of which you observe the mark near the top of each figure, is a spot at the south pole of the planet.

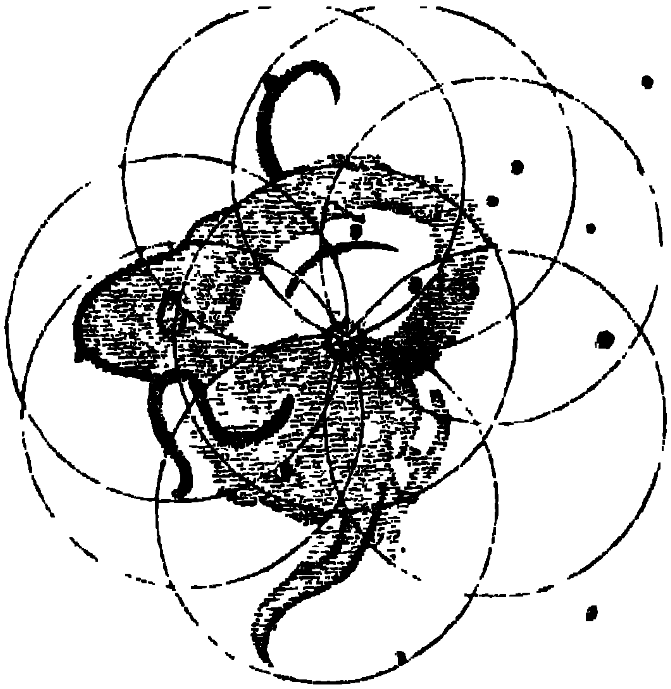


5. Water would not remain fluid on the globe of Mars, even at its equator; and in its temperate zones even alcohol and quicksilver would

freeze. This is one of the celestial bodies, therefore, where nothing like the earth's could live, either animal or vegetable. Mars has very little atmosphere.

6. The planets sometimes eclipse one another, one of them passing between the earth and the planet which it eclipses. In this manner, on the 9th of January, 1591, Jupiter was seen eclipsed by Mars.

7. In the figure which now follows, the whole of the preceding figures are exhibited



together, in a device ingeniously contrived by Sir William Herschel; thus serving to display, as in one map, all the permanent figures round the equator of the globe of Mars.

QUESTIONS.

1. How far is Mars from the sun? How long is it turning on its axis? How long revolving round the sun? At what rate does Mars travel in its orbit? What of its light and heat? Can it be seen by the naked eye? What colour is it? How does Mars appear through a telescope?

CHAP. XLI.

ABOUT VESTA, JUNO, PALLAS, CERES, AND THE PLANET DISCOVERED IN 1836.

1. NEXT to Mars, and before we arrive at Jupiter, come the five lesser, but still primary planets, which I have formerly mentioned, and which are called *new*, because newly discovered.

2. The first of these is Vesta. It is two hundred and twenty-three millions of miles from the sun, and revolves in its orbit round the sun in three years and eight months. The time of its revolution on its axis is not known. Its light is a pure white, and it may sometimes be seen with the naked eye.

3. Juno is two hundred and fifty-three millions of miles from the sun. It completes its revolution in its orbit in four years and four months, and is supposed to turn on its axis in twenty-seven hours.

4. Pallas is about two hundred and sixty-three millions of miles from the sun, and

revolves in its orbit in four years and seven months. The time in which it turns on its axis has not yet been ascertained. Its diameter is computed at little more than seventy-nine miles; so that a human inhabitant, if it had one, could go round his world in one of our steam-carriages, in the space of two or three hours! Its whole surface has been said to about equal the size of the kingdom of Spain. You will judge from this of the general sizes of all these lesser planets; for they are a little family by themselves, and have each a family likeness to the remainder.

5. Ceres is at the same distance from the sun as Pallas, but revolving in another path or orbit. It revolves round the sun in nearly the same time as Pallas. In performing its revolution, it crosses the orbit of the latter.

6. These four little planets have been discovered by astronomers but within a few years past. They are very small, and it has been imagined, by some persons, that they once formed one great planet, which was burst asunder by a

terrible convulsion, and separated into small parts. I suppose you know that stones have sometimes fallen from the air upon the earth. These stones are called aërolites, or meteoric stones. Now it has even been idly imagined, that these meteoric stones, which have also been fancied to come from the moon, and have thence been denominated selenites, have come down upon the earth through the bursting of the great planet out of which these lesser ones may have been formed! We shall have more to say, presently, about these aërolites.

QUESTIONS.

1. What are the five lesser primary planets? 2. How far is Vesta from the sun? How long is it revolving round the sun? 3. How far is Juno from the sun? How long is its revolution round the sun? How long is it turning on its axis? 4. How far is Pallas from the sun? How long is it revolving round the sun? 5. Describe Ceres. 6. Is there much known of these four lesser planets? Can they all be seen by the naked eye? What have some persons imagined? What has been imagined concerning meteoric stones?

CHAP. XLII.

ABOUT THE FIFTH NEW PLANET, OR PLANET DISCOVERED IN ITALY, IN THE YEAR 1836, BY SIGNOR CACCIATORE.

1. But *newer* still, than either of the four little planets of which I have just now told you, is a fifth little planet of this group, discovered in the year 1836, by the Italian astronomer Cacciatore.

2. I have not yet heard of any name that has been given to this planet; but its existence is confirmed to us by the testimony of the well-known and estimable astronomer and natural philosopher, M. Valz, of Nismes; who estimates its *year*, or period of revolution in its orbit, at three of our terrestrial years.

3. In my representation of the planetary system, at page 178, I have ventured to place this New Planet of Cacciatore between Mars and Vesta.

CHAP. XLIII.

ABOUT JUPITER.

1. At an immense distance beyond Mars, and beyond these lesser planets, is Jupiter, the largest planet of the system. Its diameter is eighty-nine thousand miles, and it is more than a thousand times larger than the earth. It is four hundred and ninety millions of miles from the sun, and performs its revolution round it in twelve years. It turns round on its axis in less than ten hours. Its days and nights, therefore, are not half so long as ours!

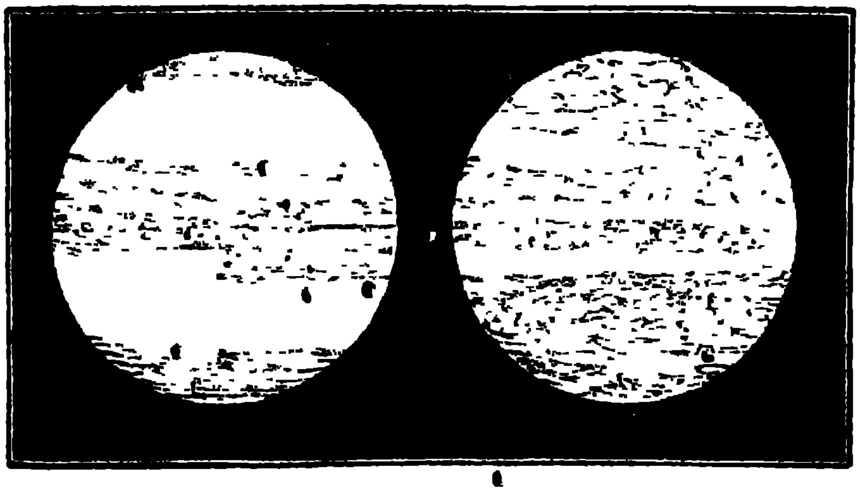
2. The degree of heat and light in Jupiter, is reckoned at twenty-five times less than on the earth. It has been said that if there is water there, it must be always frozen. It must also (it has likewise been said) be almost dark there, even during the day.

3. Jupiter is provided with four moons or satellites, the largest of which is twice as large as our moon. These moons revolve round

Jupiter in different spaces of time: the nearest goes round in about two days, and the furthest in about seventeen days. Its amount of moonlight, therefore, must be great, and much compensates, perhaps, for its distance from the sun.

4. Jupiter, when viewed through a telescope, has a great many singular appearances. Belts and bands, sometimes light, and sometimes dark, seem to extend across it, as represented in the following figures.

Fig. 1. Fig. 2.



5. In what you see here, figures 1 and 2 represent Jupiter as viewed through an achromatic telescope, with a magnifying power of forty; and figures 3 and 4, the same planet as

beheld through Sir William Herschel's great telescope represented at another page.

Fig. 3.

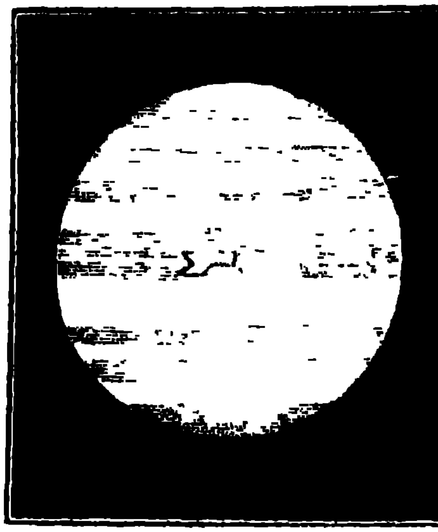
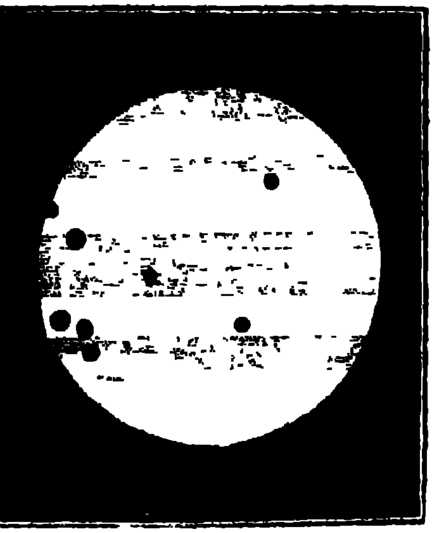


Fig. 4.



6. Jupiter, from the largeness of its mass, is a very important member of the solar system. Through the attraction of gravitation, it disturbs or influences the motions of the earth; and even its satellites disturb what would otherwise be the motions of comets. Yet (as ascertained by the process referred to at my page 81) the mass of one of those satellites (the smallest) is sixty-five millions of times less than the mass of the sun.

7. Many astronomical truths are obtained

only through observation of Jupiter and its satellites.

QUESTIONS.

1. Where is Jupiter? Which is the largest planet? What is the diameter of Jupiter? Its distance from the sun? How long is its revolution round the sun? How long is it turning on its axis? What is the length of the days and nights in Jupiter? 2. What is its degree of light and heat? 3. How many moons has Jupiter? Do they revolve round Jupiter all in the same time? 4. How does Jupiter appear through a telescope?

CHAP. XLIV.

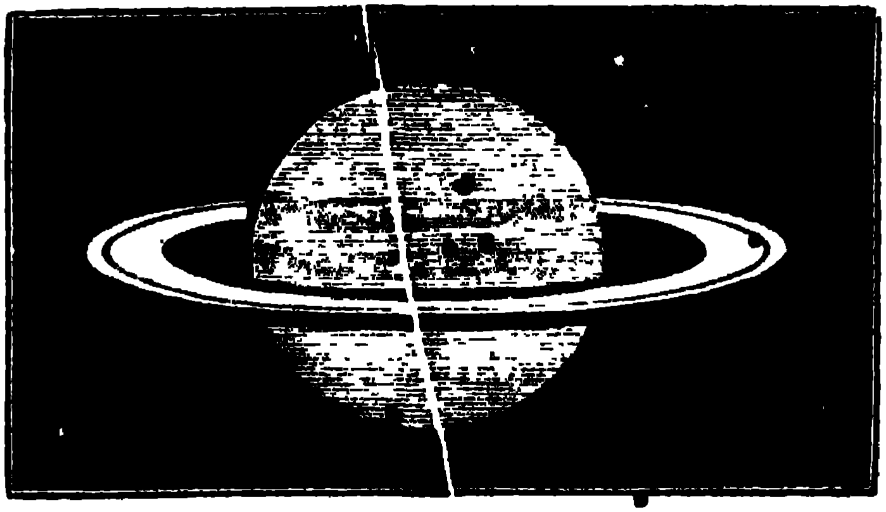
ABOUT SATURN.

1. SATURN is nine hundred millions of miles from the sun, and performs its revolution in about thirty years. It turns on its axis in little more than ten hours. It is supposed to be eighty times colder upon this planet than upon the earth. Saturn is seventy-eight thousand miles in diameter; and, excepting Jupiter, it is the largest of the planets.

2. Saturn has seven moons or satellites, which

revolve round it in different periods of time: the shortest period is one of our solar days, and the longest eighty days.

3. Saturn is surrounded by an immense thin ring, or rather by two rings, one within the other, as you see in the picture. These rings



turn round the planet from west to east, and complete their revolution in ten hours. The light of the sun, falling upon them, gives them a bright appearance, even brighter than the planet itself. When viewed through a telescope, Saturn appears to have spots and belts upon its face, like Jupiter. Stars are also sometimes seen between the two rings, and between the inner ring and the planet. The distance of the inner edge of the inner ring, from the the surface of the planet, is about thirty-four thousand miles.

QUESTIONS.

1. How far is Saturn from the sun? How long is it revolving round the sun? How long turning on its axis? Is it colder upon Saturn than upon the earth? What is the diameter of Saturn? 2. How many moons has it? 3. By what is it surrounded? Do these rings revolve round Saturn? What makes them look bright? How does Saturn appear through a telescope? What are sometimes seen between the rings and Saturn? How far is the nearest ring from Saturn?

CHAP. XLV.

ABOUT THE PLANET HERSCHEL, OR URANUS, OR THE GEORGIUM SIDUS.

1. This planet is scarcely visible to the naked eye, and little was known about it till 1781; when Sir William Herschel discovered it to be a planet, revolving round the sun; and, in honour of his august patron, King George the Third, named it Georgium Sidus, or the Georgian Star. It has since been sometimes called Herschel, and sometimes Uranus.

2. This planet is at the prodigious distance of one thousand eight hundred millions of miles from the sun. It performs its revolution round the sun in eighty-four years. The time in which it turns round upon its axis is not known. It is three hundred and sixty times colder upon Uranus than it is upon the earth, and the degree of light is called three hundred and sixty times less. There are six satellites or

moons revolving round this planet, but not a great deal is known about them.

QUESTIONS.

1. Is Herschel a planet? When was it found to be one? What other names has it? 2. How far is Herschel from the sun? How long is it revolving round the sun? What of its light and heat? How many satellites or moons has Herschel revolving round it?

CHAP. XLVI.

ABOUT THE MOTIONS OF THE PLANETS.

1. I MUST now beg the particular attention of my little readers to what I am going to say. The planets, or planets and asteroïds, of which I have been telling you, have each of them two motions. That is, they all turn round from west to east, in the same manner as the earth, of which I told you a little while ago; and they also move in vast circles round the sun. To make you understand this better, suppose you put a small stick through the centre of an

apple, and call the stick its axis. Now, turn the stick round, and see the apple turn with it. Very well! The apple turns round on its axis.

2. In a similar manner, each of the planets turns round upon its axis. The earth turns round upon its axis every day, or once in twenty-four hours. Some of the planets turn round upon their axes in a shorter time than the earth, and some of them in a longer time.

3. Now, suppose you take an apple, and tie a string to the stem of it, and whirl it about your head. We will call the circle, or path in which the apple flies about your head, its orbit. So, if you whirl it swiftly, the apple will go round in its orbit, or go round your head, a hundred and fifty times in a minute.

4. Now the planets go round the sun in their orbits, or in great circles, just as the apple tied to a string flies round your head. Some of them are nearer the sun than others; and, not having as far to go, for that reason they complete their journey round the sun in a shorter space of time.

5. The earth goes round the sun in its orbit once in a year, or three hundred and sixty-five days, and the whole distance which it travels in this time is truly wonderful. It is more than five hundred millions of miles. The rate at which the earth moves in its path is nearly fifteen hundred thousand miles a day. We, who live upon its surface, proceed along with it in its journey; and are therefore borne along at the prodigious rate of about sixty-four thousand miles an hour, or about eleven hundred miles a minute!

6. This is truly an amazing subject for contemplation. While you are counting one hundred, you are carried through space eleven hundred miles!

QUESTIONS.

1. What two motions have all the planets and asteroïds? 2. How often does the earth turn round upon its axis? What is the axis of the earth? What is the orbit of the earth? Do all the planets turn round upon their axes in the same time? 4. Do all the planets revolve round the sun in the same time? 5. How long does it take the earth to go completely round the sun? What number of miles does the earth travel

in completing one revolution round the sun? How many miles does the earth travel in a day? How many miles are we carried through space upon the earth in an hour? How many in a minute?

CHAP. XLVII.

PARLEY TELLS ABOUT THE SECONDARY PLANETS, OR SATELLITES, OR MOONS.

1. I HAVE told you something about all the primary planets, or planets more commonly so called; but I have not yet told you about the secondary planets, or moons, or satellites, or attendants upon some of the primary planets.

2. A satellite is anything that follows or attends upon another. The moon is called a satellite because it follows or attends upon the earth.

3. The earth is not the only planet that has a moon, or satellite, or secondary planet to accompany it. Jupiter has four, Uranus has six, and Saturn has seven.

4. These satellites or secondary planets of

Jupiter, Saturn, and Uranus, are called *moons*, only because they resemble the moon, which is the single satellite, or secondary or attendant planet, of our primary planet the earth.

QUESTIONS.

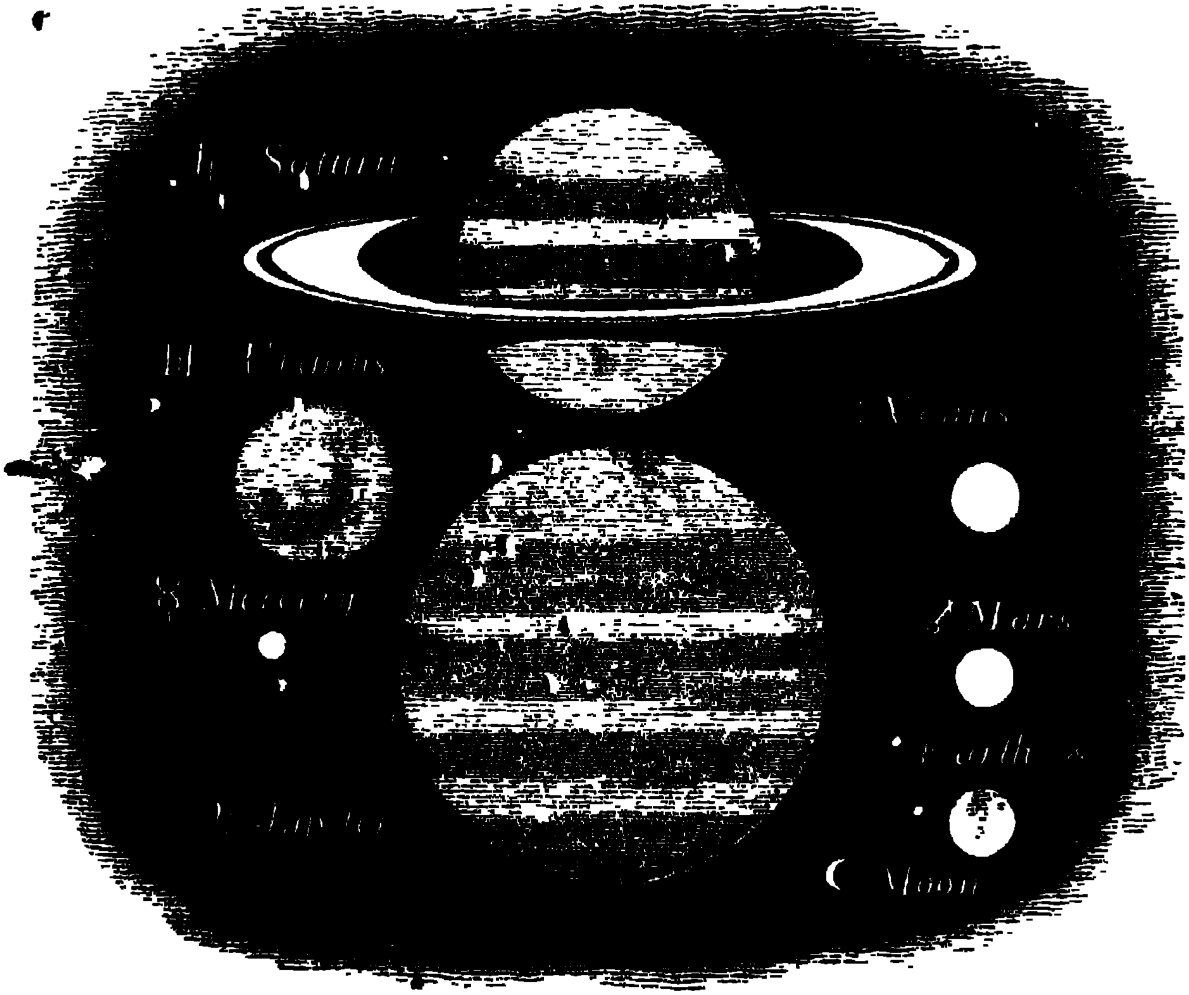
1. What about secondary planets? Satellites? Moons? 2. What is a satellite? Why is the moon called a satellite? 3. How many satellites or moons has Jupiter? Saturn? Uranus? 4. Why are the satellites of Jupiter, Saturn, and Uranus called moons?

CHAP. XLVIII.

ABOUT ALL THE PLANETS TOGETHER, AND ABOUT THE ORBITS OF THE PLANETS.

1. I HAVE now told you about all the planets belonging to the Solar System. As I have told you before, they all revolve round the sun, from west to east, in great circles, called their paths or orbits. Some of these planets are nearer the sun than others. The nearest is Mercury, which is thirty-seven millions of miles from the sun. The furthest off is Herschel, or Uranus, or the Georgium Sidus, which is eighteen hundred millions of miles from the sun.

2. These planets are of various magnitudes or sizes. The smallest is Mercury, which is much smaller than the earth; the largest is Jupiter, which is at least one thousand two hundred times as large as the earth. The following picture shows you the comparative sizes of the planets.



3. All these planets, so far as known, turn on their axes, or perform their diurnal revolutions, in different spaces of time. Jupiter turns in little less than ten hours, which is the shortest time. Mars turns in twenty-five hours, which is the longest time in which any planet performs its diurnal revolution. Thus Jupiter has the shortest, and Mars the longest days and nights,

of any of the planets. It appears that the largest planets turn, or revolve on their axes, in the shortest time.

4. As planets move at different distances from the sun, the orbits or circles in which they move are of different lengths. Consequently, they move around the sun in different periods of time. The shortest period is that of Mercury, which is about three months. The longest period is that of Uranus, which is about eighty-four years.

5. All the planets are round, or nearly round, or spherical. The earth is about twenty-five miles further through, at the equator, than at the poles; it is not, therefore, a perfect round, or sphere, or globe. It is called a spheroïd, by which is meant a globe or sphere-like figure, but not a perfect sphere or globe. It is supposed that the other planets also are spheroïds.

6. The planets move in their orbits with different degrees of velocity; those nearest the sun the swiftest. Mercury moves at the rate of one hundred and ten thousand miles

an hour, or one thousand six hundred and sixty-six miles in a minute. While you can walk across a room, it flies two hundred miles!

7. Venus moves at the rate of seventy-six thousand miles an hour; the earth at the rate of sixty-four thousand, and Mars at the rate of fifty-five thousand miles an hour.

8. The planets being at different distances from the sun, receive different degrees of light and heat. At Mercury, the heat and light are supposed seven times as great as upon the earth. If any of our animals or plants were carried from the earth to Mercury, they would immediately perish, from the excessive heat. If there are such creatures there, they must be imagined of different natures from those of the earth.

9. The degrees of light and heat at Uranus are assumed as three hundred and sixty times less than upon the earth. Even during the day, that is, when the sun is shining upon that distant planet, the light, as it must seem to us probable, is very dim, like our twilight. The

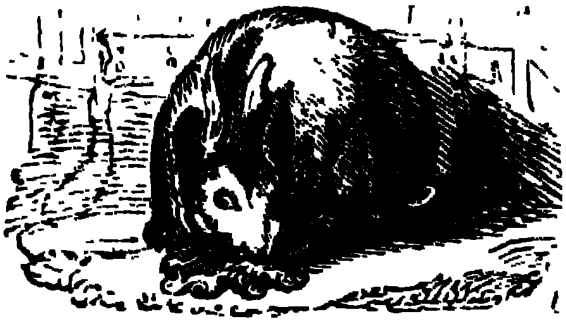
cold must be greater than we can conceive. Any of the plants or animals of our world would be instantly frozen to death there. There can be no water there; for in such a degree of cold, it would be instantly converted to ice, as solid as our rocks.

10. You remember that several of the primary planets have moons, or satellites, or secondary planets, revolving around them. The earth has one, Jupiter four, Saturn seven, and Uranus six; in all, eighteen.

11. Thus I have told you of the seven larger primary planets, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, and Uranus. I have told you of the five asteroïds, or lesser primary planets, counting the planet so lately discovered by Cacciatore. I have also told you of the eighteen satellites or moons which move in their orbits round their several primary planets; and I have told you of the two great bright rings which move round Saturn.

QUESTIONS.

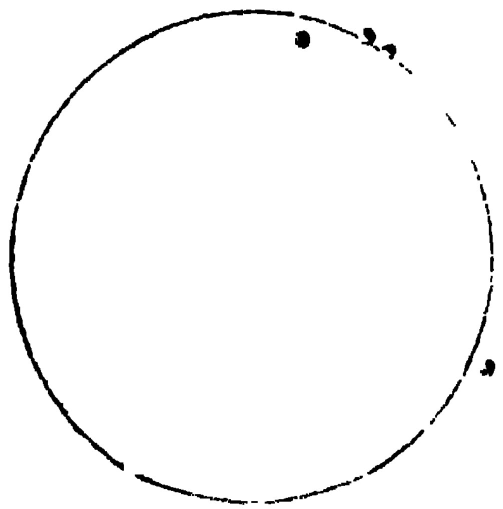
1. In what direction do all the planets revolve round the sun? Which planet is the nearest to the sun? Which is the furthest from the sun? 2. Which is the smallest planet? The largest? How much larger is Jupiter than the Earth? 3. How long is Jupiter turning on its axis? How long is Mars? Which planet has the longest days and nights, and which the shortest? 4. How long is Mercury revolving round the sun? Is this the shortest period? What is the longest revolution round the sun? 5. Are the orbits of the planets round? What figure are they? Are all the planets round? Why is the earth called a spheroïd? 6. Do all the planets move with the same velocity? Which planets move the swiftest? How far does Mercury travel in an hour? In a minute? 7. How far does Venus travel in an hour? How far does the earth travel in an hour? Mars? 8. Have all the planets the same degrees of heat and cold? What degrees has Mercury? What would happen to our animals or plants, if they were taken to Mercury? Could the same creatures live in Mercury, that live on the earth? 9. What of the light and heat at Uranus? What would become of animals or plants in Uranus? Can there be any water there? 10. How many satellites, or moons, or secondary planets, are there in the Solar System? What planets do they belong to?



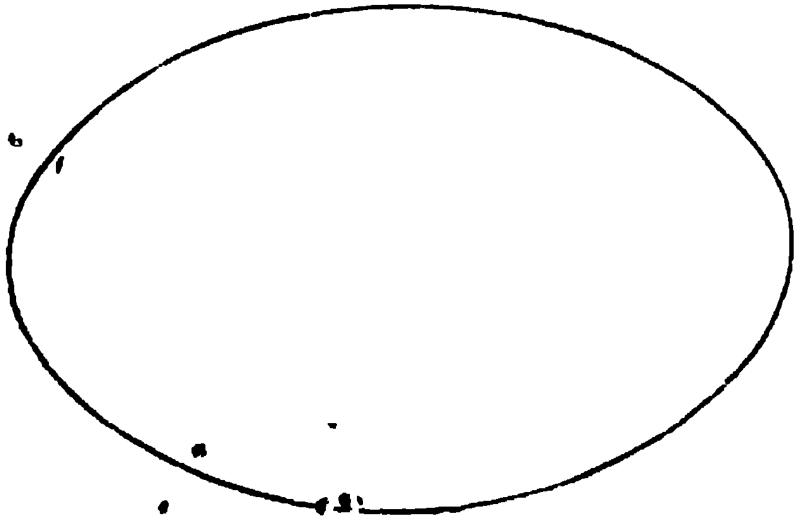
CHAP. XLIX.

ABOUT THE ORBITS OF THE PLANETS.

1. I MUST not omit to tell you that the orbits or paths in which the planets move, are not perfect circles, but on the contrary, are all elliptical; that is, they are a little longer one way than the other. The following are pictures of a circle and an ellipsis. The ellipsis shows the form of a planet's orbit.



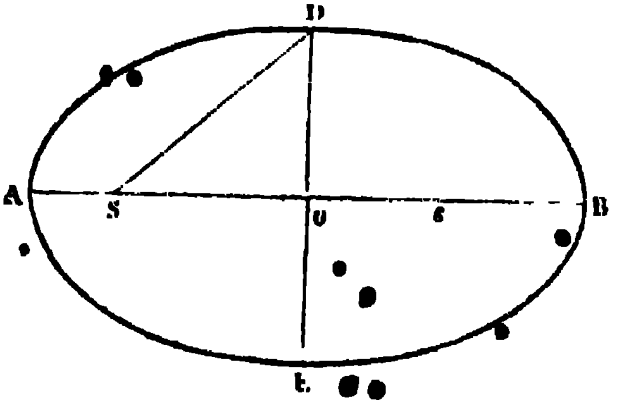
Circle.



Oval, or Ellipsis.

2. The planetary orbits, as I have told you, are ovals, or ellipses; and it is in that elliptical figure alone, that either the primary planets round the sun, or the moon or other satellites round the earth, or round the other primary planets, do really move. The sun, or earth, or other planets, (s) is not really the centre (c) of their motion, or of their *orbit*, A D B E; but is always far away upon one side, as *s* C, or else far away upon the other, as C *s;* and it is from this same figure of the planetary orbits, that the planets, primary, and secondary, are always varying, as they perform their revolutions, their

distances from the sun, or from the planets round which they revolve.



3. You can easily discern, for example, that when a planet is at A or B, it is much nearer to the sun, or the earth or other planet, S or *s*, than when it is at D or E.

CHAP. L.

ABOUT COMETS.

1. I HAVE told you of thirty heavenly bodies revolving round the sun; that is, of twelve primary planets, and eighteen moons, satellites, or secondary planets. But these are by no means all the bodies belonging to the Solar System. It is even probable, that there are still many planets, whose size is so small, or their distance from the earth so great, that they have not yet been perceived. We must certainly add, however, those that are among the most remarkable of the heavenly bodies, and which we call comets. These appear like feeble stars, with fiery or at least luminous appendages. Sometimes these appendages are faint in light, and short in length. Sometimes they are so long as to reach half across the sky. The tail of a comet seen in the year 135 of the Christian

era, is said to have been as long as the Milky Way.

2. Sometimes comets appear very small, and like dim stars. Sometimes they are larger, and it is recorded that they have been seen as large as the moon, and even as the sun. Like the planets, they belong, as I have said, to the Solar System.

3. Comets appear only occasionally, or at certain intervals of time, embracing a greater or less number of years. I, however, have seen several. When I was a boy, I recollect that there was a very brilliant comet. Many people were very much alarmed, for fear the world was to be burned. I remember to have heard of an old woman, who drowned herself, because she was afraid of being burned to death by the comet!

4. Comets revolve round the sun like the planets, except that their orbits are far from being so nearly circular, but on the contrary they are exceedingly elliptical, or of an oblong oval. Some of them pass round the sun at a

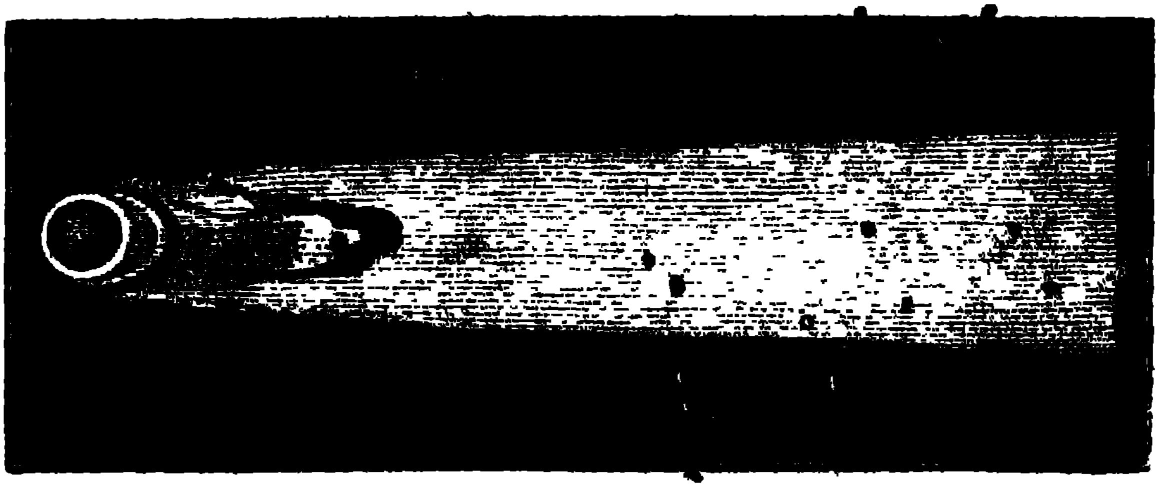
shorter distance than Mercury, and then shoot through an immeasurable space, even beyond the orbit of Uranus. Most comets we know so little of, that when they disappear it is impossible to tell when or whether they will return. There are a great many comets; five hundred are recorded as having been seen since the beginning of the Christian era; that is, within the last one thousand eight hundred and forty-one years.

5. Comets, you will remember, revolve round the sun, and form parts of the Solar System. Some are supposed to be but a few years in performing their revolutions, and others several hundred years.

6. Many comets are always invisible to the naked eye. It is believed that, visible or invisible to the naked eye, at least two comets approach the sun, and make their circuit round it, within the period of each year. The telescope discovers to us this real frequency of comets.

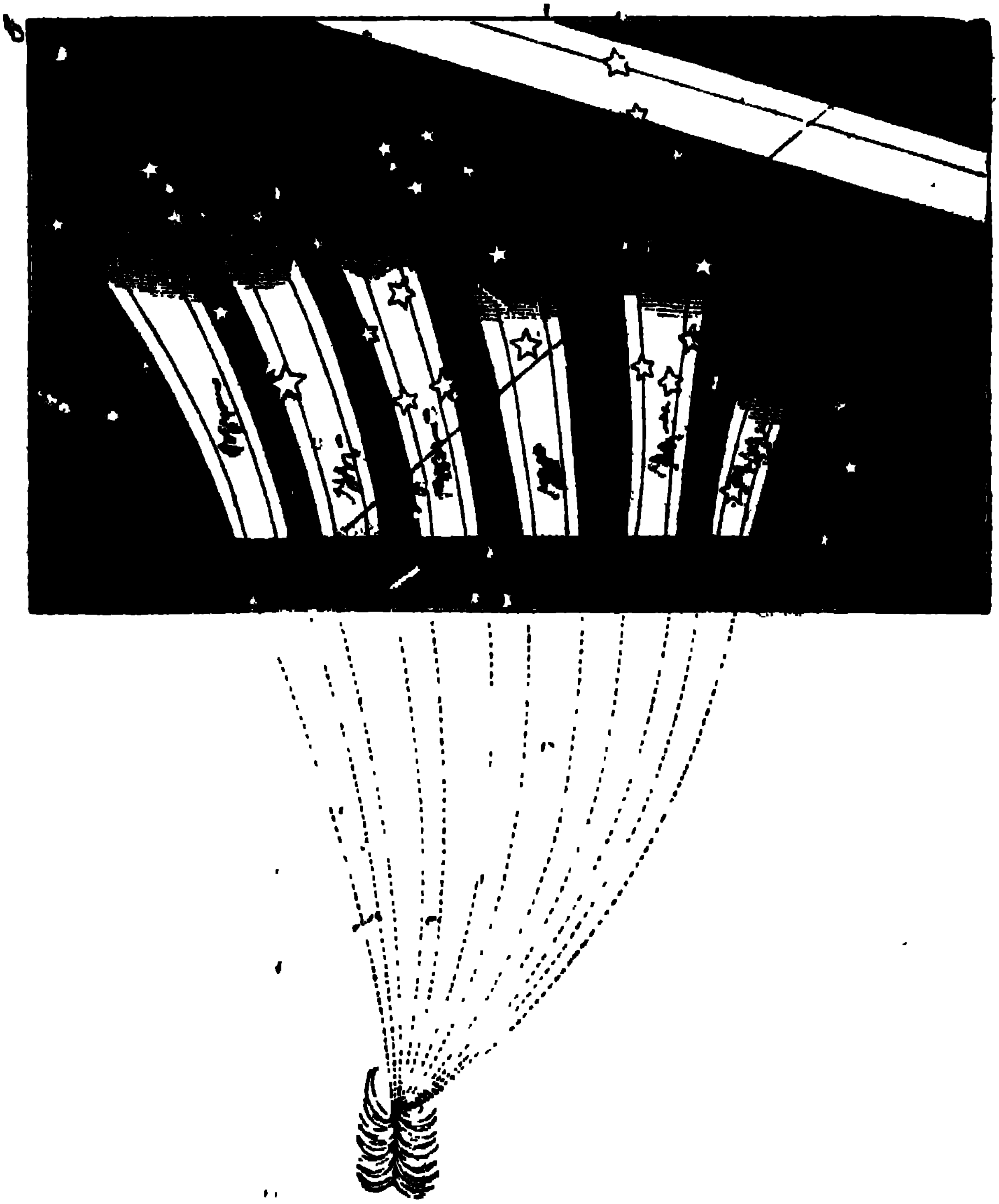
7. Of the extraordinary figures of particular comets there are numerous accounts. What

you see is part of that of the celebrated comet of 1680, as represented by M. Lemmonier, in



which you observe the nucleus or disc, and part of the lengthened tail.

8. The figure over leaf is that of the comet of 1744, according to M. Chezeaux; and one of the most remarkable upon record. The tail is divided into six branches, all diverging like the sticks of a fan, and between them the stars are visible. Remarkable, however, as was the figure of this comet, I wish you to take particular notice of it, because of its resemblance to the *telescopic* accounts of the comet of 1835 and 1836.



9. [a]The nucleus of the comet, and the roots,

as it were, of the tails, appear in that part of the figure which is only outlined. My little readers must suppose a vast space in the heavens, between the upper part of the outlines and the finished ends of the tails. These, however, in this comet, were only reckoned at a length of thirty degrees; whereas, the simple tails of many have exceeded sixty degrees, and even ninety.

QUESTIONS.

1. What are among the most remarkable of the heavenly bodies? How do comets appear? Are the tails of comets long or short? 2. Are comets of different sizes? 4. Do comets revolve round the sun? What is the form of their orbits? What is an elliptical orbit? How near do comets come to the sun? To what distance from the sun do they sometimes go? Do we know much of comets? How many of them have appeared in the last one thousand eight hundred and forty-one years? 5. Do comets form parts of the Solar System?

CHAP. LI.

SOMETHING MORE ABOUT COMETS.

1. COMETS, or cometary *stars*, have their name from the word *coma*, signifying "hair;" so that the real meaning of the word *comet*, is "*hairy* star." But again, by "hair," in speaking either of a comet, or of the sun, is meant its *rays of light*, or the light which either appears to issue from it, or by which it is surrounded. It is because of the *rays of the sun*, that Apollo (the personification of the sun, or the sun spoken of as if it were a man or person) is said to have yellow or golden hair. And thus it is that you must understand the name of "hairy star," and the expression of the "horrid *hair*" of a comet, when Milton says, that Satan

———"like a Comet burned,
That fire the length of Ophiuchus* huge
In th' Arctic sky, and from his horrid *hair*
Shakes pestilence and war;"—

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* The name of a constellation.

where, also, you find an allusion to the superstitious belief in mischievous influences from comets.

2. But this *hair* or *spreading light*, of a comet, is seen, at different times, in very different forms and directions, and is therefore very differently named. You know the nursery rhyme—

> "I saw a *peacock* with a fiery *tail*."

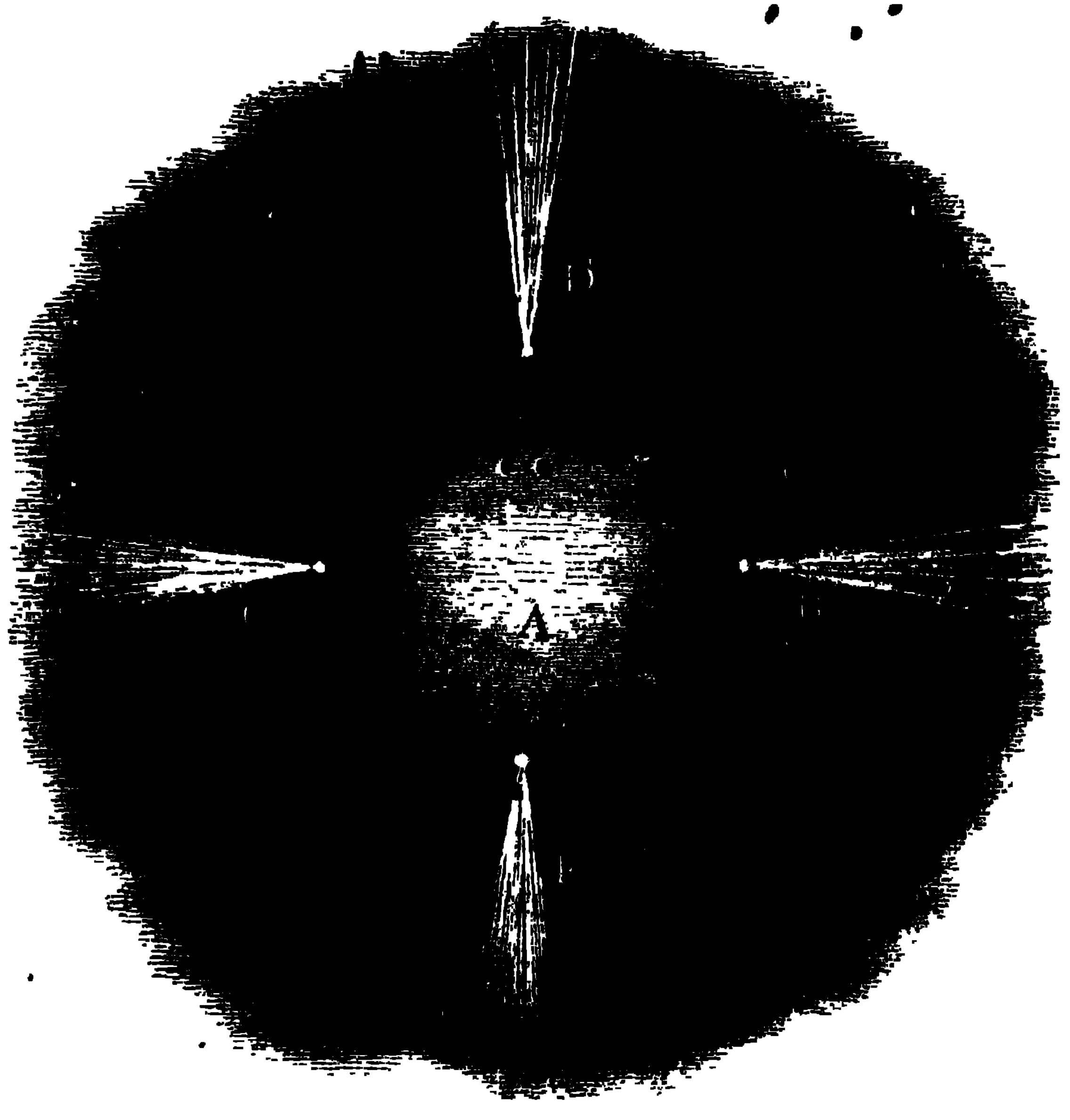
and here, the *tail*, otherwise called the *train*, is the name given to the *hair* or *light*. But the same light is otherwise called the *beard*; and thus comets are sometimes spoken of, not as *tailed stars*, but as *bearded stars*.

3. The reason why the *spreading light*, or *spreading hair*, of a comet, is sometimes called its tail, and sometimes its beard, is (as I have now led you to guess) that it sometimes goes *before*, and at other times *behind*; and it is the cause of this change in the direction that I am now going to explain. A comet is always either approaching the sun, or else going from

it; but, whichever of these two ways it moves, its *spreading light* is always upon that side which is turned from the sun, and not upon the side nearest to it. That is, it never points toward the sun, but always away from it; so that it sometimes comes *before* the comet, and sometimes *follows* after.

4. For the present, you must suppose that *every* comet is in itself a globe or ball, like the sun or moon, or like any other star or planet; including the earth, our own ball or globe. Now these balls or globes of the stars, and planets, and comets, are likened, in our imagination, to human or other *heads;* though, in respect of a comet, the head is also called the *nucleus*, or kernel, or that essential body, or comet properly so called, to which the rest belongs. See, then, as a comet goes round the sun, with its hair or spreading light always pointing *away* from the sun, how various its position will seem to us to be, in respect of its own nucleus or head. For, here, A being the sun, B a comet approaching the sun, and C the

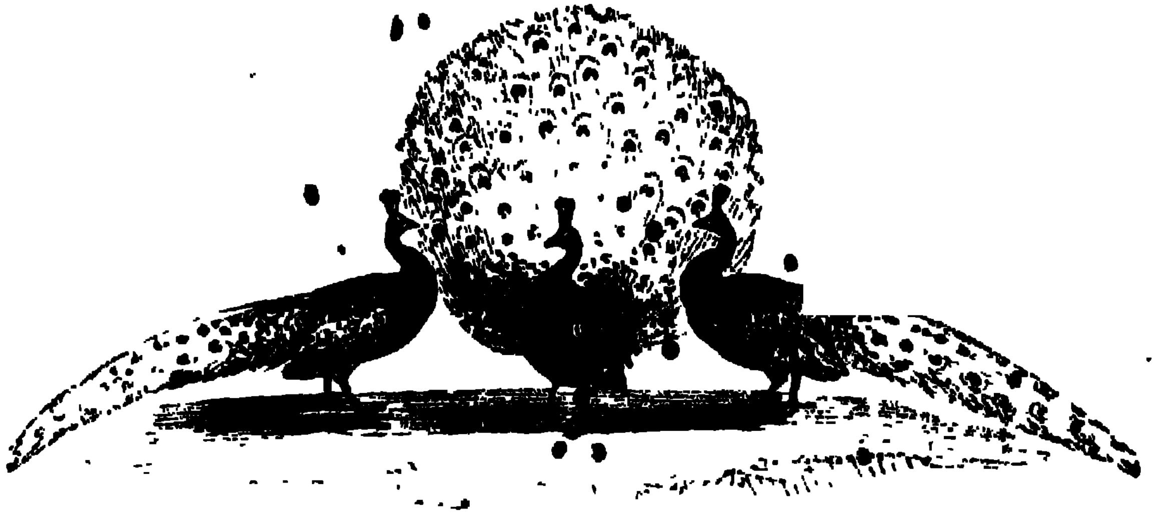
same comet departing from it; then, the comet as represented at B will be said to have a *tail*, or



hair, or tail or train of light *behind* its nucleus, or head, or body; while the same comet, as represented at C, will be said to be *bearded*, or to have hair projecting in *front* of the nucleus, head, or body, or *chin*. For, to our eyes, the first will seem to *follow* the comet, and the second to come *before* it.

5. Nor are these two aspects the only ones in which the same comet, in different parts of its course, can show itself to us. We may see it, (as at D and E, or at any point between B and C and C and B,) foreshortened more or less, and showing neither at one end nor the other its spreading *hair* or *light* behind it, but (more or less) it will seem to be *around* it; like the rays of the sun *around* the sun, or like the tail of a peacock, in the second of the following three positions: for, here, A and C will represent the two side views of the same comet, and B the front; while, if we had a back view of the same bird, with its head or body visible through a transparent tail; then, these front and back views (B and its companion) would answer to the figures D and E in my diagram, and show us when the spreading *hair* or *light* of the

comet (spreading much wider, and higher and lower, than the head or body of the comet) would seem to surround it, like what we call a



glory, or like the constant *hair* or *rays* of the sun; as well as suggest to us, through all the points between, how it might appear more or less lengthened, or more or less circular.

6. But this leads us to the understanding of other names of comets. Sometimes, they are neither called *bearded stars*, nor yet said to have trains, or trails, or *tails*, but are spoken of as *blazing stars*, without more particular description; and this is more convenient when their spreading hair or light neither *follows* them, nor

comes *before;* but appears to surround them like a man's hair his head, or like his mane the head of a lion, or like its rays the sun itself.

7. Comets have also been seen without any tail, beard, hair, or *coma,* whatever.

8. It has long been known that the tails of comets consist but in their vapoury and transparent substance, through which the stars behind them may be seen.

9. But the heads or nucleuses of comets appear, at least in some instances, to be equally transparent, showing the stars through them.

10. It also appears that the light of comets, however effulgent in itself, shows dimly when brought into contrast with the light shining from a star of even the ninth magnitude.

11. According to M. Arago, more than seven millions of comets are continually passing and repassing across the planetary orbits of our system.

CHAP. LII.

ABOUT HALLEY'S COMET, OR THE COMET OF 1835 AND 1836.

1. The comet which, in conformity with the calculations of Dr. Halley, appeared in 1835 and 1836, was of high importance to the cometic branch of astronomy; but, to the naked eye, it had little either of that splendour, or that singularity of figure, which have so much contributed to make the history of comets generally striking.

2. Its importance consisted in the verification, by its appearance at that particular time, of the calculation of Dr. Halley, from whose name it is called Halley's Comet.

3. Its appearance, in conformity with the calculation, supported the doctrine, that comets are permanent bodies, and move in fixed though eccentric orbits, and are not of the transitory nature of meteors, as many had come to suppose. On that account, the year 1835 had been looked forward to by astronomers with extraor-

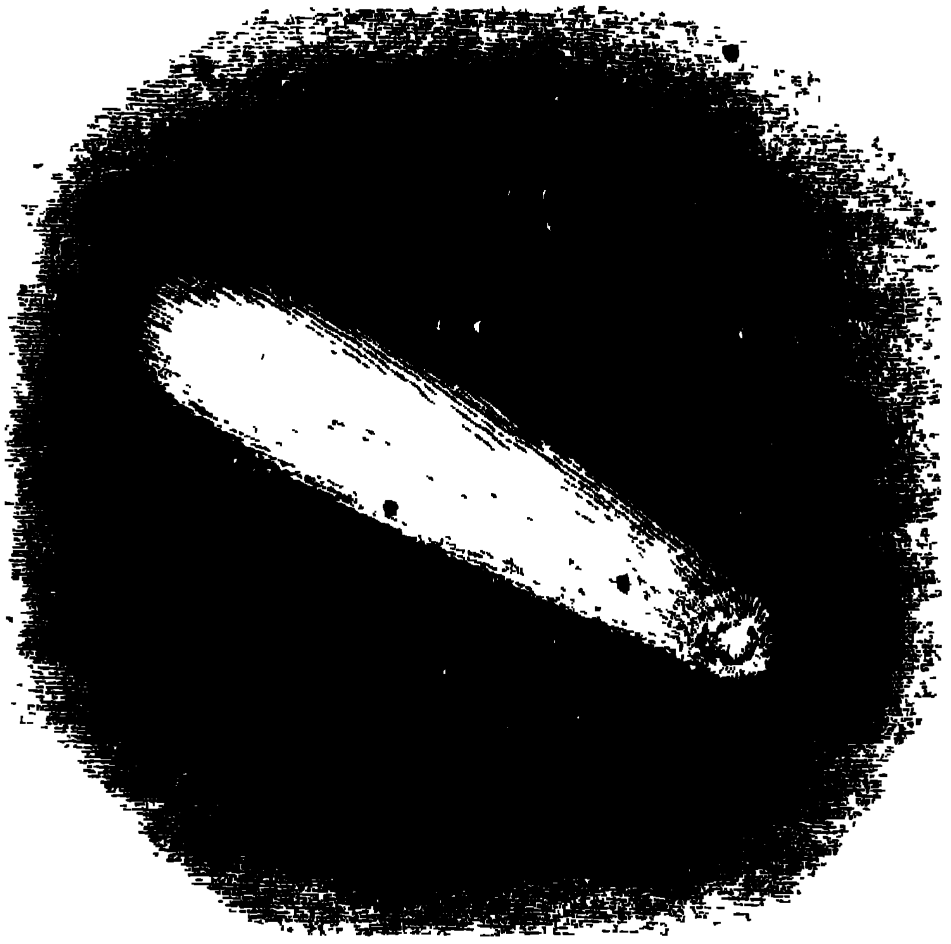
dinary interest; and, whether the calculation was to be successful or to fail, had been called "an epoch in astronomy."

4. Dr. Halley was a man of the most brilliant and diversified capacity and acquirements, who lived in the time of Newton. He died in the year 1742; but, upon astronomical grounds which were offered by Newton, his study of the cometic phenomena had led him to believe and publish, that the comets of the years 1456, 1531, 1607, and 1682, were returns of one same comet, thus periodically seen at intervals of either seventy-five or seventy-six years; or, in other words, thus performing its revolution round the sun in one or other of those periods.

5. It followed, that he predicted its returning again in the year 1758, or 1759; and it actually did return and become visible at the end of December, 1758; and reached its perihelion on the 12th of March, 1759.

6. Its reappearance in the year 1835 was exactly at the time, and in the very place, assigned to it by the astronomical prediction;

and its actual arrival at its perihelion* a little before noon on the 16th of November in that year, differed from the computed time only by a small number of days.



7. "The fulfilment of the astronomical predic-

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[*] For the meanings of the words *perihelion*, *aphelion*, and *nucleus*, see the notes a little further on.

tion," says a writer whom I have before quoted, "is truly wonderful, if it be considered that the comet is seen only a very few weeks during its passage through our system, and that it wanders from the sun for seventy-five years, to twice the distance of Uranus. This enormous orbit is four times longer than it is broad; its length is about three thousand four hundred and twenty millions of miles, or about thirty-six times the mean distance of the earth from the sun.

8. "At its perihelion, Halley's comet comes within nearly fifty-seven millions of miles of the sun; and at its aphelion it is sixty times more distant. On account of this extensive range, it must experience sixty times more light and heat when nearest to the sun, than in the remote point of its orbit. In the one position, the sun will seem to be four times larger than he appears to us; and at the other, he will not be apparently larger than a star."*

9. In point of figure, and as seen by the

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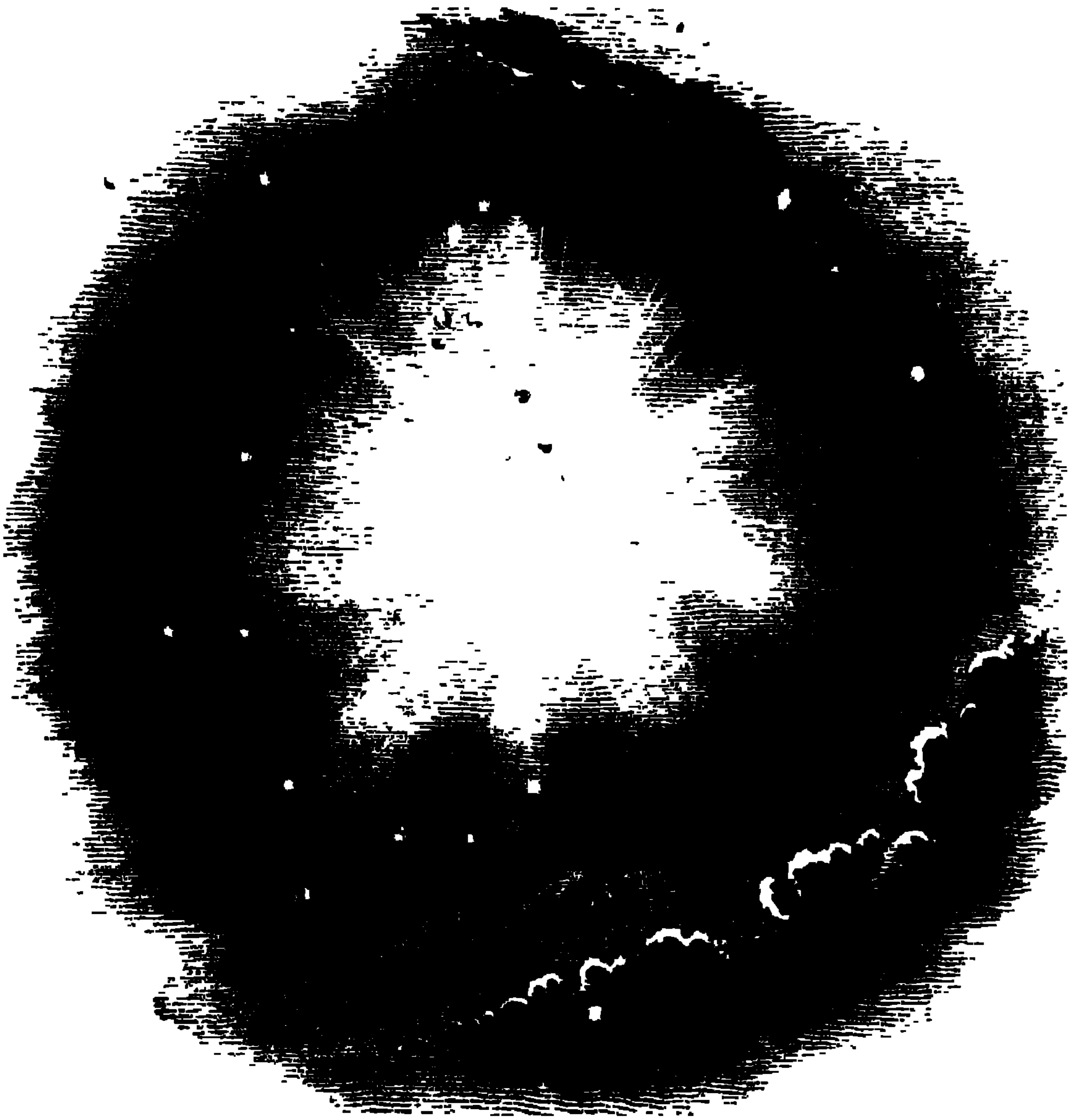
* Somerville's Connexion of the Physical Sciences.

naked eye, or even by the help of ordinary telescopes, the appearance of this comet in 1835 and 1836, (for the same comet has different forms at its different appearances,) had little that was remarkable; or, in other words, was of the more accustomed kind. But, to astronomers, both in the Northern and in the Southern hemispheres, it presented very peculiar and interesting sights.

10. On the first appearance of this comet, early in the month of August, 1835, it seemed merely a globular mass of dim vapour, without a tail. According to observations of M. Valz, at Nismes, this vapour-like or nebulous body, which was the comet, increased in magnitude as it approached the sun; but no other comet upon record, ever exhibited such sudden and unaccountable changes of aspect. The nucleus, which had become clear and well-defined, like the disc of a planet, was seen, upon one occasion, to grow apparently larger, as well as less bright, in the course of a few hours. But, more remarkable than even this, was its sudden dis-

play of luminous branches or sectors, diverging from the nucleus through the beard or nebulosity which surrounded it. M. Struve describes the nucleus, as seen by him in the



beginning of October, elliptical in shape, and like a burning coal, out of which there issued, in a direction nearly opposite to that of the tail, a divergent flame, varying in intensity, form, and direction; appearing occasionally even double, and suggesting the idea of luminous gas bursting from the nucleus. On one occasion, M. Arago saw three of these divergent flames on the side opposite to the tail, which latter they greatly exceeded in brilliancy.

11. Hevelius describes an appearance of this comet precisely similar, at its approach to the sun in the year 1682; and something of the same kind, in another comet, has been shown in the figure in my preceding chapter.

12. The appearances of Halley's comet in the Southern hemisphere, on its return from the sun in 1836, are described with very similar circumstances to those observed in the Northern, in the autumn of 1835.

13. "I am sure," says Sir John Herschel, (writing, in the middle of 1836, from the Cape of Good Hope, to M. Arago,) "you will be

interested in learning that I have here been favoured with a long and beautiful exhibition of the comet, on its return from the sun. It was in sight from the 24th of January till the 5th of May [1836.] In its passage from its perihelion,* it must have been seen with great difficulty in Europe, for its physical aspect was quite changed [from what it presented on its approach.] For a long time it had no tail; the parabolic envelope of the head was formed with such astonishing rapidity, that its visible volume more than doubled in the space of twenty-four hours. I may say, without exaggeration, that I saw it augment; for, on the morning of the 26th of January, on repeating my micrometric observations† of the well defined part, after an interval of three hours,

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* *Perihelion* is the name of that point in the orbit of a planet which is *nearest* to the sun. It is formed from two Greek words; *peri*, near, and *helios*, the sun. *Aphelion* is the name given to the point exactly opposite to the perihelion; or that at which a planet or comet is furthest *away* from the sun, or at its greatest *distance*.

† *Micrometric* observations are observations made with a *micrometer*, an instrument for measuring *small* spaces; of which the name is derived from the Greek *micros*, small, and *metron*, a measure.

I found an increase in its linear dimensions equal to a sixth-part of the whole! This extraordinary dilatation continued, and the paraboloïd became so large and lustreless, that it at length entirely disappeared, leaving only the nucleus and the tail of the star.* Another, and a singular peculiarity, was the existence of a very small interior comet, having a head and tail complete—its nucleus was that of the general mass. This cometic nucleus dilated less rapidly than the envelope; and at the end of the period of being visible the tail itself became imperceptible."

14. This, then, is the first comet of which at least the moderns have established the reality of the periodical returns. It is also the first comet of which the elements or distinguishing characters have been determined from observations made in Europe; for, although the comets which appeared in the

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* The word *nucleus* properly means a *kernel* or *nut*; but also anything about which other things are gathered.

years 240, 539, and 887, of the Christian era, are the most ancient of those whose orbits have been traced, their elements were computed from Chinese observations.

15. Authentic records of Halley's comet extend backward only to the year 1456; but there are traces that are probable, though not absolutely certain, to periods before the Christian era.

CHAP. LIII.

ABOUT SHOOTING OR FALLING STARS. ENLARGED IDEAS OF THE SOLAR SYSTEM. THE NOVEMBER ASTEROIDS.

1. We might now think that we had done with our outline of the bodies composing the Solar System; and this, till very lately, would have been the case. The sun, the primary planets, secondary planets, satellites, or moons, and the long list of comets; these, till very lately, composed what was regarded as the entire assemblage of the Solar System. Much more, however, is at present talked of; and, as it is always my wish to make my little readers acquainted with the very newest, as well as oldest particulars of knowledge, or of what is received as knowledge; I have some remarkable statements to make, though without answering that at least part of them will not hereafter be disputed, if not entirely rejected. In natural history, as in natural philosophy,

and in many other branches of human science, it is right that those little ones should know, how often things which are for some time supposed to be certainly true, come, at another time, to be considered as certainly false.

2. I hardly believe that such as listen to me can find, in any other book, so many hints about the riches that are contained in the heavens, or in the total ethereal space, beyond the simple list of sun, moon, and stars. But, if some modern astronomers are right, there is still more to add. "A new planetary world," says M. Arago, "begins to open upon us!" Lately, accounts of vast showers of shooting stars, observed in many parts of the Northern Hemisphere, (including Europe and Asia, as well as America,) and always on or about the same day of the same month; and these accounts have given encouragement to a belief, that there exists in the Solar System a zone of millions of minute planetary bodies, revolving in groups around the sun; one of which groups, under concurrent circumstances, meets the

earth on its revolution in its orbit, at the point which it passes yearly between the 11th, 13th, or 14th of the month of November.

3. The possible existence of other members of the Solar System than those so long familiar to us has been readily admitted. Planet after planet, and comet after comet, is successively discovered. Besides the little planet discovered by Signor Cacciatore in 1836, M. Wartmann, of Geneva, reported, in 1831, his observation of a celestial body which had the appearance of a star of the seventh or eighth magnitude, but which moved like a planet; and which, having lost sight of it through cloudy weather, he has never yet been able to behold again. Having laid down, upon a sheet of paper, the positions of certain stars near which the planet Uranus was to pass, he saw, on the following night, that one of them had changed its place. He watched its motion for two months, during all which time it continued its progress, which was in the contrary direction to the order of the signs of the zodiac.

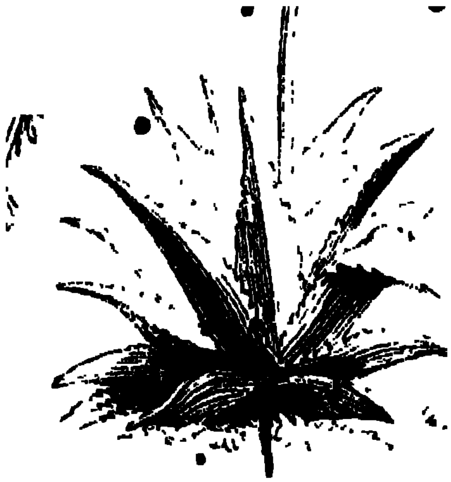
It remains to be known, whether this, too, is a planet to be hereafter added to our histories.

4. Laplace believes the attractive power of the sun to fill a sphere, of which from the centre to the circumference is a distance of a hundred millions of times greater than the distance of the sun from the earth. Remember that this latter distance is ninety-five millions of miles; making, of the whole, ninety-five hundred millions of miles. But Uranus itself is only nineteen times more distant from the sun than even our distant earth; while the solar attraction continues beyond Uranus itself eighty-one times the distance of the earth! Here is ample room, then, both within and without the orbit of Uranus, for the existence of members of the Solar System with which we are still entirely unacquainted! There may be both small bodies and large, belonging to the Solar System, never yet hitherto discovered from the earth, and which must continue undiscovered from it for ever!

5. But M. Arago has fancied the discovery

of new millions of at least small bodies. I have told you of that gentleman's estimate of the comets of our system at a number exceeding seven millions, and now I am to add, that he believes we have some countless millions of small planetary bodies; primary but minute planets, moving, in throngs, in a single orbit which surrounds the sun!

6. The belief of M. Arago arises out of some late observations of an annual appearance of shooting or falling stars, now spoken of as the annual appearance of the "November Asteroïds." Now of this I am going to tell you more.



CHAP. LIV.

MORE ABOUT SHOOTING OR FALLING STARS. ABOUT STAR-JELLY, OR STAR-SHOT, OR NOSTOC. ABOUT FIRE-BALLS AND AEROLITES.

1. You have often seen shooting or falling stars. Perhaps you have seen sky-rockets also. If you have, you may also have found some small resemblance between the two; for, at least, the shooting or falling stars, after running, for an instant, through the sky, appear to burst in the air, and to disperse themselves in shining sparks, which soon fade and vanish, or become extinct.

2. Perhaps you have even run to the spot where you thought the extinguished sparks must have fallen, in order to find their substance; as, perhaps, you have also run after rocket-sticks, toward the spots where they have seemed to fall. If you have done none of those things, at least others have done so, both before and since you were born!

3. But, though we know the appearance of these shooting or falling stars, what, in reality, are they; and of what nature is the substance which it has been supposed possible to find and pick up, after it has fallen, and become dark and cold?

4. These have long been subjects of different opinions, though never, till now, of the opinions lately advanced. Shooting or falling stars have generally been held as *no stars at all*, but only *meteors;* or bodies which belong to *the atmosphere of the earth.*

5. I must mention them again, and more at length; but as, at present, some suspect them to be really *stars*, or at least planetary bodies of our system, I am obliged to speak of them in the very Tales which you are reading.

6. Shooting or falling stars have been considered *fiery meteors.* Fiery meteors are exhalations from the earth, and move only in our atmosphere, and not in the great heavenly space. They are always seen, and sometimes heard also, to explode; and the explosion is often known to

be followed by the fall of meteoric stones: the whole, as to the manner, (though upon a scale so immeasurably larger,) like the explosion of a sky-rocket, and the fall of its sparks, and paper, and stick. But I must add no more to the history of meteoric stones.

7. Fiery meteors of large sizes are called fire-balls, but these are of rare appearance. Those comparatively small are frequent, and are called falling or shooting stars; and while, from the explosions of some at least of the former, we derive the earthy and metallic substances at present called either aërolites or air-stones, or meteorites or meteoric stones; the multitude, if not the philosophers themselves, have sometimes fancied that, *as to their substance,* the latter fell upon the earth in the shape of a gelatinous or jelly-like substance, which has been called "star jelly" and "star-shot;" and to find which, at the supposed falling or shooting of a star, boys and men have run, just as we now see them run to find a rocket-stick!

8. A gelatinous substance is occasionally

found on the grass, and even sometimes on the branches of trees, the origin of which the modern learned do not ascribe either to stars or to meteors; but which they are divided as to regarding either as an animal or vegetable production. The vegetablists name it *tremella nostoch*,* and say that it is a fungous plant, quick of growth, and of short duration, but of which even the seed has been discovered; but the animalists, though differing from each other in subordinate respects, agree in affirming it to be the altered remains of dead *frogs*. "The quantity of jelly," says one of these, "produced from one single frog is almost beyond belief; even to five or six times its bulk when in a natural state;" that is, when the frog is in a living state —as the writer means to express himself.

9. I am not about to fix the origin of this

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* Or *nostoc*; for *nostoch* has been reproved as a wrong spelling. "Tremella, in botany," says Withering, "a genus of the class cryptogamia, order algæ. Tremella-nostoc is not uncommon after rain, in grass-fields and gravel walks, and is vulgarly supposed to be the remains of a meteor or fallen star." Darwin, as I shall mention presently, keeps to its origin, frogs.

substance, but only to confirm what I have said of its anciently supposed origin in meteors, if not in stars. "There is found on the grass, by sides of rivers," says an animalist in this controversy, "large lumps of a kind of dusky jelly, of which the common people have an idea that it drops from the stars, and call it, if I mistake not, *star-jelly*."

10. "In the north of England," says another, "this substance is generally known amongst the country-people by the absurd name of *fallen stars*."*

11. "From a child," commences a third, "I remember seeing the meteors shooting in the air, which appearance, by my comrades, was called star-shooting; believing the *stars* no larger than their apparent magnitude. This jelly-like substance was believed to be the dross of these meteors, and took the name of *star-shot*, which passed for certain with me till I had arrived at the age of twenty-four."†

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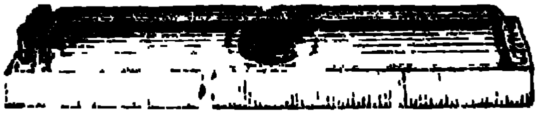
* Gent. Mag. 1793. p. 137.

† Gent. Mag. 1776.

12. Such, in England, and throughout the world, were some of the notions entertained concerning shooting or falling stars, and concerning their supposed material and its nature, a very few years ago; and I think it will amuse you to contrast their humility with the exalted character which is just now assigned to both. From expiring in a substance which might be mistaken, either for a vegetable fungus, or for the remains of a dead frog, they are now elevated into planets; and from resemblances to the productions of the fire-work maker, born and bursting in the air above us, and to be picked up over the next stile; we view them now as celestial bodies, whose proper orbit surrounds, not even the earth itself, but the same sun which is the centre of Jupiter, Saturn, and Uranus!

13. The very learned, indeed, even at the time referred to, had no belief (it is just possible) in the story of the *nostoc*, whether that substance were animal according to some, or vegetable according to others. They thought, as most of us, (though without being very learned,) till this

twelvemonth past have continued to think, that the shooting or falling stars were *meteors*—fiery meteors—fiery exhalations, and chemical combinations in the atmosphere; inflammations of hydrogen gas, or substances somewhat of that nature. They likened them to the Will-o'-the-wisps, or *ignes fatui*, or *wild-fires* of the marshes; and still, to all these shining appearances they were fond of attributing what they called an "unctuous or fatty substance." Here, then, was the opening for the persuasion, that in the substance called star-shot, or star-jelly, or *nostoc*, was found a substance, which, if not really "unctuous or fatty," was yet the real substance of a shot or fallen star; and here (even its starry origin became doubtful) was still a substance of which it was disputed, whether it were vegetable, or derived to us from frogs? The philosopher and naturalist, Dr. Darwin, held to the frogs.



SHOWERS OF SHOOTING OR FALLING STARS REPORTED TO HAVE BEEN SEEN AT BOSTON, AND IN OTHER PARTS OF NORTH AMERICA, ON THE THIRTEENTH AND FOURTEENTH OF NOVEMBER, 1833. OTHER EXAMPLES OF THE SAME OR SOMEWHAT SIMILAR PHENOMENA, IN THE SAME AND IN OTHER PLACES, YEARS, AND MONTHS.

1. For three or four years, news has reached us from the United States of North America, that in a large part of the country, in the middle of the month of November in each year, and generally upon the same day of the month, (that is, upon the night of the thirteenth, or morning of the fourteenth day,) whole showers of shooting-stars, illuminating all the atmosphere, have been seen during the entire night and longer.

2. As to their numbers, as reported to have been observed at Boston, in November, 1833, they are said to have succeeded each other so instantaneously that it was impossible to count them; and the most moderate estimate calls

them hundreds of thousands. They were so numerous, and showed themselves in so many quarters of the heaven at the same time, that the attempts to reckon them were only the roughest guesses. At the Observatory, their number was considered equal to one half of the flakes of snow which fill the air during an ordinary fall. When their numbers were diminishing, six hundred and fifty were counted in fifteen minutes, in a part of the heaven which did not comprise a tenth part of that visible horizon which was filled with them; and these stars did not amount to more than two-thirds of the whole number seen, which was at least eight hundred and sixty-six; giving, for the whole hemisphere, eight thousand six hundred and sixty. But the display was incessant for seven hours; and this number, taken when the numbers were moderated, but multiplied by four, gives thirty-six thousand six hundred and forty per hour, or per sixty minutes; or two hundred and forty thousand for the whole seen at one particular point of observation!

3. The phenomenon presented itself along the whole eastern coast of North America, from the Gulf of Mexico at least as high as Nova Scotia, from nine o'clock in the evening till sunrise; and, in some places, in full daylight, till eight o'clock in the morning.

4. Over a still larger surface, both in America and Europe, these thousands of shooting-stars, with larger bodies among them, were seen in November 1799, the first date at which they are thought to have been recently mentioned; but not again till November, 1831, or after an interval of thirty-two years.

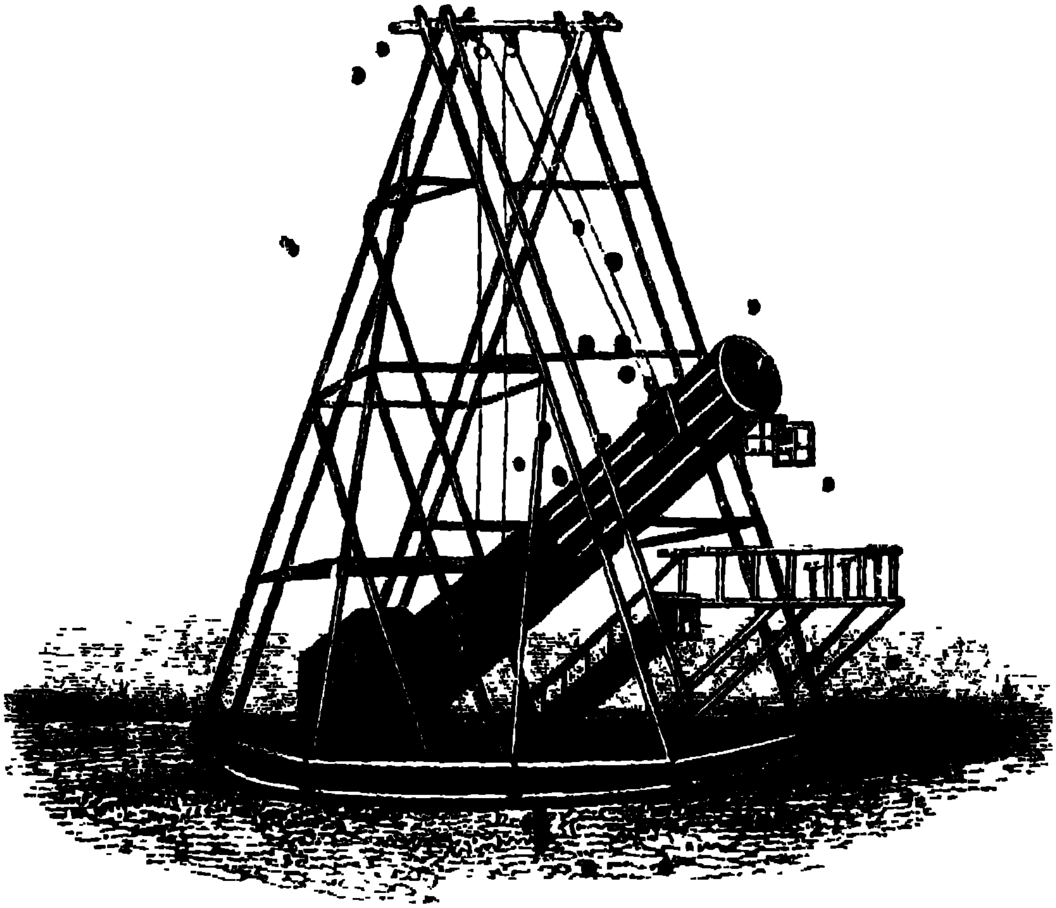
CHAP. LVI.

SHOOTING OR FALLING STARS OBSERVED BY SIR JOHN HERSCHEL, AT THE CAPE OF GOOD HOPE, ON THE MORNING OF THE FOURTEENTH OF NOVEMBER, 1835.

1. As a consequence of the American statements, our eminent astronomer, Mr. Baily, lately requested Sir John Herschel, who is at the Cape of Good Hope upon astronomical researches, to take notice whether anything extraordinary appeared in the southern heaven, in that part of the globe, on or about the anniversary of the night in question.

2. Now Sir John looked out accordingly, on the nights of the 10th, 11th, 13th, 14th, and 18th of November, 1835; and nothing remarkable was to be seen upon the three first of those nights, nor upon the fifth; but at four o'clock in the morning of the 14th of November, the date assigned in North America, Mr. Stone (Sir John's assistant) suddenly exclaimed,

"There goes the largest I ever saw;" and then described that he had seen a momentary



shining body, which, in the telescope, had seemed no smaller than the planet Jupiter.

3. Half an hour after, M. Stone again exclaimed, "There goes another great one;" and just before five o'clock, "I absolutely started from the eye-piece of the telescope," says Sir

John himself, "at the glare of a superb one! Stone thought it lightened, though his back was to it, and it was hid from him by trees. It left a narrow, vivid, and distinctly crooked train, which lasted twenty seconds, and admitted of being steadily contemplated. This meteor was equal to Venus [even] at her brightest *here*!"

4. Sir John Herschel concludes his account with a remark, that the actual appearance of these luminous bodies in the month, and on the day, when he had been taught to look for them, was a coincidence which, though remarkable, he was still inclined to think accidental.

5. But the statements now recited make us curious as to what corroboration they have received from other witnesses of those appearances themselves, and what there is upon record as to any former time.

6. We have accounts of this November shower of shooting or falling stars in the year 1831, both from the country of the Ohio, and

from the coast of Spain; and each with reference to the night of the 13th. The second of these two is from the commander of the French brig Le Loiret.

7. In the years 1832 and 1834, the showers were reported from the Atlantic, from the Red Sea, from Switzerland, and from several parts of England.

8. But November is not the only month of the year in which these showers have been seen, or are to be looked for. "It is desirable to make observations between the 20th and 24th of *April*, as well as in November; for in 1803, on the 22nd of *April*, I believe, from one o'clock in the morning until three, shooting-stars were seen in all directions in such great numbers, in Virginia and Massachusetts, as to be compared to a shower of sky-rockets."

9. Now there has been produced, since the writing of this sentence by M. Arago, an extraordinary extract from the pages of an old chronicle, actually containing an account of a shower of falling stars, witnessed in

Europe, in the month of *April*, eight hundred and thirty years ago.

10. An anonymous correspondent communicates the following curious passage to the French Academy of Sciences, almost copied from a Latin chronicle of Baldric, printed at Leipsic in 1807; "which adds," says the writer, "another testimony concerning the occurrences of the phenomenon of Falling Stars. 'Already, before the Council of Claremont, the *stars* had announced the progress of Christianity; for innumerable eyes, in France, saw them fall from heaven, as thick as hail, on the 25th of April, 1095.'"

CHAP. LVII.

OBSERVATION OF THE NOVEMBER ASTEROIDS IN EUROPE, IN THE MONTH OF NOVEMBER, 1836.

1. M. ARAGO bestows upon the luminous appearances of which we are now speaking, the name of *asteroids*, or star-like, or planet-like bodies; a name which, for many years, had been given and confined to the small new planets between Mars and Jupiter.

2. The reported appearance of these bodies in North America in the month of *November*, in the years 1831, 1832, 1833, and 1834, successively, having been the circumstance to fix the attention of the astronomers and philosophers of Europe upon their history, the distinctive name of "*November* asteroïds" has also been employed for them; and thus, perhaps, my little readers may be allowed to

understand, that when they read of asteroïds in general, the five small planets are generally intended; while, by the term "*November* asteroïds," it is the shooting or falling stars of the month of November that are spoken of.

3. We have no similar report from North America since the year 1834; but since that year (chiefly through the zeal of M. Arago,) much has been collected and published in Europe upon the subject.

4. It is stated that in November, 1835, a large and brilliant luminous body fell near Belley, in the department of Ain, in France, and set fire to a farm-yard; and that, at the same time, either this or another, but larger and more brilliant than Jupiter, was observed at Lille, where, upon exploding, it left in the sky a shower of sparks precisely similar to those which fall from a sky-rocket. Still, there is here but little that resembles the *American* phenomenon, the date excepted; though the description agrees remarkably with what we have seen related by Sir John Herschel as to

the phenomena upon the same night, at the Cape of Good Hope. In neither, have we any *showers of stars.*

5. On the night of the 18th of November, 1836, an anxious watch for the reappearance of shooting or falling stars was kept at the Observatories, and in other situations, in several parts of France, Germany, and Holland, and other countries of the continent of Europe; and even in England, the Ashmolean Society at Oxford engaged the *Superintendent of the Police*, to look carefully for the event. The Superintendent of the Police reported to the Ashmolean Society, that on the night or morning in question, he had seen *six* of these luminous bodies; and in Holland, Germany, Paris, and various other places in France, numbers, from one to one hundred and seventy, but generally from fifteen to forty, were seen at the same time. Still, the American *showers* would be wholly wanting, were it not that, in the neighbourhood of Tours, the country-people declared that dur-

ing the night they had seen a *rain of fire;* and that, near Culloy, in the valley of the Rhone, the same authorities are said to have reported, that through a heavy fog they saw lights in the heaven, succeeding each other with such rapidity that *they* thought them to be flashes of lightning, or else a repetition of the brilliant aurora-borealis which they had witnessed on the night of the eighteenth of October preceding. Such, as to its dates, is the latest part of the history of the appearance of the November asteroïds.

CHAP. LVIII.

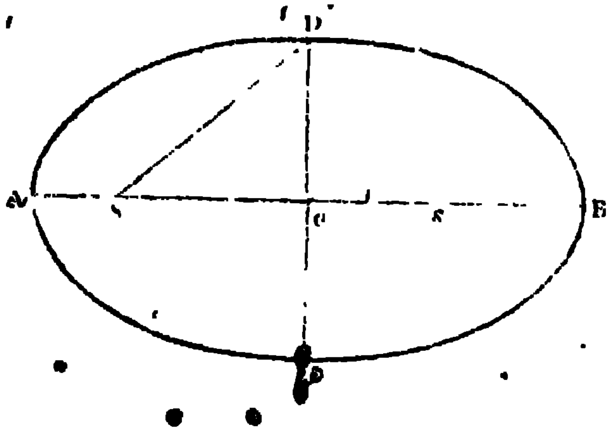
M. ARAGO'S EXPLANATION. MR. OLMSTED'S EXPLANATION. M. BIOT'S SUGGESTED EXPLANATION. THE ZODIACAL LIGHT. SUGGESTION THAT SHOOTING-STARS, FIREBALLS, AND THE ZODIACAL LIGHT ITSELF, ARE ALL ELECTRICAL PHENOMENA, AND THEREFORE METEORS ONLY. ACCOUNT OF THE PHENOMENON OF THE 13TH OF NOVEMBER, 1833, AS SEEN FROM BALTIMORE TO NEW YORK, GREATLY DIFFERENT FROM THE ACCOUNTS FROM BOSTON, AND ENTIRELY IN CONTRADICTION TO THE PLANETARY FANCY.

1. To explain the appearances in question, M. Arago offers the doctrine of which I have before spoken; namely, that there exists in the solar system a zone of millions of minute celestial bodies, revolving in groups around the sun; one of which groups, under concurrent circumstances, meets the plane of the ecliptic toward the point which the earth occupies yearly between the 11th and 13th of November.

2. M. Arago supposes that these minute and multitudinous *planets*, or what he calls *asteroids*, are dark, and therefore invisible

unless they enter our atmosphere, where they take fire, and consume.

3. M. Arago proceeds further. He thinks that the group of shooting-stars which was seen on the 13th of November, 1834, performs its revolution round the sun in a period of about one hundred and eighty-two days, in an elliptical orbit, whose major axis, or greatest diameter (A B) is one hundred and eighteen millions of miles; and that at its aphelion distances, (D and E,) at which (in November and April) it comes in contact with the atmosphere of the earth, is about ninety-five millions of miles, or nearly the mean distance of the earth from the sun. The interval of non-appearance, between November, 1799, and Novem-



ber, 1831, M. Arago attributes to a disturbance of the orbit; and adds, that a similar cause may produce future intervals of a similar non-appearance.

4. Mr. Olmsted, of North America, has published some comprehensive works upon the American appearance of what he denominates *meteoric stars*, on the 13th of November, 1833; and supposes it the consequence of the earth's encounter—not with a zone of *planets*—but with a great meteoric cloud, which he describes as constantly circulating round the sun.

5. M. Biot differs, more or less, from both these astronomers, but approves of Mr. Olmsted's latest opinion, concerning the probability of a connexion between these *stars* and the Zodiacal Light. M. Biot wholly inclines to the opinion that they belong to the Zodiacal Light. M. Biot supposes the earth to meet with the Zodiacal Light; and the shooting or falling stars to be parts of its material.

6. The Zodiacal Light is a triangular beam of light, rounded a little at the vertex or top,

which, at certain seasons of the year, is seen before the rising of the sun, and after its setting. In this climate (says Brewster's Edinburgh Encyclopedia) it is always most distinct about the first of March, at seven o'clock in the evening.

7. It is reputed to have been first observed by Descartes, and after him, in 1659, by Childrey; but chiefly brought into notice by Domenico Cassini, in 1688.

8. At first, Cassini imagined the Zodiacal Light to arise from an immense number of small planets, circulating round the sun; in the same manner that the brightness of the Milky Way is occasioned by the light of a great number of stars. This persuasion he afterward abandoned, and then believed it to consist in the luminous atmosphere of the sun. The second conjecture has long been universally followed; but Laplace and others pronounce that it cannot be the true one.*

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* Yet it is often still so represented in many of our books; as, in the instance of Mrs. Somerville's Connexion of the Physical Sciences, p. 399. 3rd Edition.

9. "The great Cassini," says M. Biot, "at first conjectured, that the solar nebule was formed by an innumerable multitude of little planets, circulating round the sun, like the visible planets Mercury and Venus. At a later period, it was supposed that it might be the atmosphere of the sun, but as such an hypothesis will not accord with any of the established laws of mechanics, it has been abandoned; and M. de la Place concluded, as Cassini had done before him, that the substance of the nebule is not the atmosphere of the sun, but that the molecules which compose it circulate round this star, as so many planets would do, if placed at similar distances from its centre; and it is evident, moreover, that they would not be sustained without the aid of a centrifugal force, which prevents them from being precipitated upon him."

10. "Cassini," says, also, M. Biot, "discovered that the body of the sun is enveloped by a vast nebule, similar to a whitish light, spread circularly round him at a great dis-

tance from, but in the direction of, his equator. The limits of this phenomenon are evidently not susceptible of any exact determination; it can only be perceived in those parts of the sky where the nebule is large, and thick enough to send forth such a quantity of rays as will become visible to our eyes, but it is doubtless prolonged beyond the limits of our sight. Its general appearance is like a double lance-head, or two pyramids opposed to each other, having the sun for their base; which is merely an optical effect, produced by the projection of its sensible outlines against the sky."

11. My little readers will thus perceive, that M. Arago has not been the first to imagine the sun surrounded by a moving zone of millions of small planets; but that he has probably been really the first to suppose such planets *dark* planets, and planets displaying light only upon the accident of their entering into the atmosphere of the earth, and of their taking fire in consequence. "Messier," says

M. Arago, "states, that on the 17th of June, 1777, toward noon, he saw, in the space of five minutes, a very large number of black globules pass over the sun's disc. Were not these globules," he asks, "asteroïds?"

12. There have always been difficulties about distinguishing fiery meteors, seen in the sky, from stars, and stars from fiery meteors, which last are supposed to move only in the atmosphere of the earth. Comets were long regarded as no more than fiery meteors; and fiery meteors have always had some observers to contend that they were *stars*, or at least *planetary* bodies. Halley believed fire-balls to be secondary planets of the earth, moving round it like the moon.

13. But an opinion different from either I have yet mentioned, is not without its advocates. It is, that fire-balls, shooting-stars, and even the Zodiacal Light itself, are all but phenomena of the *electric fluid*, displayed at a great height above the surface of the earth;

and all of a somewhat kindred nature to the Northern lights, or Auroræ Boreales.

14. Space does not allow me to say more upon that subject here, nor to give you the very minute account which has been published of the shower of shooting or falling stars of the 13th of November, 1833, as seen in the neighbourhood of Baltimore, and thence to New York; all in North America, but very dissimilar to the accounts from Boston.

CHAP. LIX.

ABOUT THE SUPPORT AND MOVEMENTS OF THE HEAVENLY BODIES. ABOUT THE EARTH AS ONE OF THESE. ABOUT THE PERPETUAL ORDER OF THE SOLAR SYSTEM.

1. WHILE I have been talking, however, of the sun, and moon, and stars; of the nebules, planets, comets, and of all this multitude of minor celestial bodies at present supposed to be contained and moving in the heaven; and even of the earth itself, as contained and moving like the rest; your little minds, my dear and eager listeners! have been busy with perplexing thoughts, as to how these bodies are supported in the heaven, how they are made to move in it, and how they are made to move with regularity, and come back, day after day, year after year, and thousands of thousands of years, to the same places with respect to each other, and to the same places in the heaven? You conclude, that there is some power, some force, which accomplishes

all this; and you ask me, what is that force, that power, or by what means these wondrous things are done?

2. It is very natural, for example, when we see or hear of even the planets only, travelling so swiftly, to inquire why they always keep moving round in the same paths? Why they always revolve in the same manner round the sun? Why they do not break away from their orbits, and fly into distant and unknown regions of space?

3. To these questions I might answer, that God keeps them always in their places. And this answer would be true; but yet God works by means. He makes the grass grow, but he does it by means of sun and rain. He keeps the planets in their orbits, but what are the means by which he does so? This is what I am now going to tell you. All bodies possess attraction; by this I mean, that all bodies mutually draw each other by an unseen power, called attraction. If you throw a stone into the air, it comes down immediately to the earth.

We say it falls, but why does it fall? Because the earth attracts it, or draws it back again.

4. It is by this power of attraction that the inhabitants of the earth are kept on its surface. Those on the other side of the earth remain just as firmly upon it as we do, because the earth attracts all things that are in, or upon, or (as we see with its atmosphere) around its body.

5. Well: the sun has the same power of attraction as the earth, so the sun attracts the earth, and the earth attracts the sun. The consequence is, that these two bodies, the earth and sun, are inclined to come together. In other words, the earth is powerfully drawn toward the sun; and, unless it were in some way prevented, it would immediately set out, and go to the sun.

6. But how is the earth prevented from taking that journey? I will tell you. When a body is set in motion by being thrown forward, it is inclined to proceed in a straight line. Now the earth has such a motion; and consequently, were it not restrained, it would by force of this

motion fly away from the sun. But it is prevented from doing so, by the attraction of the sun. The attraction of the sun gives the earth a circular movement, and thus keeps it in its orbit.

7. To make you understand this perfectly, I beg you to look at my picture of a boy whirling an apple round his head. The apple is drawn toward the boy by a string, just as the

earth is drawn toward the sun by attraction. The apple is thrown forward; and, if the string were to break, it would fly off in a straight line. But the string holds it fast, and, giving it a circular movement, makes it pass round the boy's head, just as the earth in its orbit passes round the sun.

8. This is the place, too, where I should speak of those distinguished French astronomers, Lagrange and Laplace, whose brilliant demonstrations have made it certain, that every variation of the planetary motions is but periodical, or regularly alternate, like that of the pendulum of a clock; and that therefore (contrary to what had been previously apprehended) the order of these motions is indefinitely permanent, being subject to no change but such as is periodical.

CHAP. LX.

OF THE CENTRIFUGAL AND CENTRIPETAL FORCES.

1. Thus you see that the planets (the earth inclusive) are kept in their place by opposition of two powers, or forces; which forces, I must now tell you, are called the centrifugal and centripetal forces. The centrifugal force is the motion by which the planets are thrown forward, or disposed to fly away from its centre, the sun; and the centripetal force is the power of attraction, which keeps them in their orbits, and, instead of disposing them to fly away from the sun, to move continually around it.

2. In the case of the boy, the centrifugal force is that given to the apple, which would make it fly away if the string were to break. The centripetal force is the string which keeps it from flying away, and gives a circular direction to its motion.

3. All the planets, and the sun itself, are

endowed with the power or force called attraction of gravitation. The sun gravitates to the planets, and the planets to the sun; just as I said of the gravitation of the earth to the moon, and the moon, in its own turn, to the earth; but the sun, being by far the greater body, attracts them more powerfully than they attract the sun. Consequently, they would rush to the very body of the sun, if they were not kept from doing so by their centrifugal forces.

4. They are kept, therefore, in their places by two powers or forces; a projectile power, which inclines them to fly off in a straight line, called the centrifugal force; and a power or force of attraction, which inclines them to go toward the sun, and gives them their circular movement, and is called the centripetal force.

5. I have no room, however, to tell you about Professor Mozotti, of Corfu, and the belief in but a single force.

CHAP. LXI.

OF SOME OF THE IMMEDIATE USES TO MANKIND, AND TO ALL LIVING CREATURES, OF THE LIGHTS OF THE SUN, MOON, AND STARS.

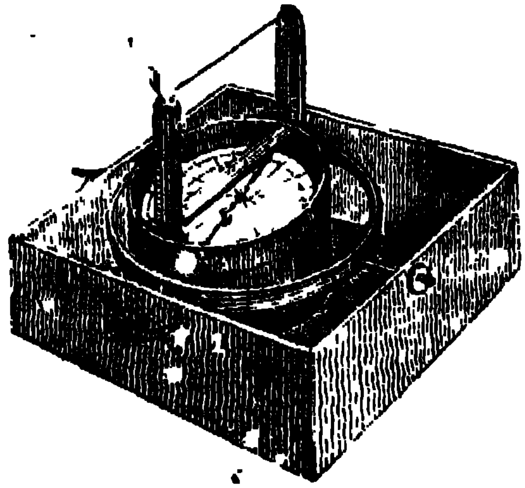
1. THE sun, moon, and stars, whatever else either science or reflection may discover in them, are *moving lights;* and there are infinite uses belonging both to their lights and to their motion.

2. I shall tell my little readers only a few and very partial things upon these great subjects; but there are some among them which I will not omit to mention.

3. Except the pole-star, or polar star, (called by our Anglo-Saxon ancestors the "lode-star," or "lead," or "leading star,") we make very little particular *use,* at present, either of the fixed stars, or of the stars in general, or of our telescopic and scientific knowledge of them. The pole-star, as my little friends have seen,

"leads" or directs our *eyes* to the north pole of the heaven; but as, when the heaven is clouded, the pole-star cannot be seen, and as our acquisition of the magnet, or "load," or "lode," or "leading stone," by guiding or directing our *understanding*, if not to the poles of the heaven, at least to the *magnetic poles* of the earth, has made our actual or constant sight of the pole-star of the less importance to us, even when sailing by starlight

in a ship at sea; even the pole-star has lost a degree of its *utility* to us, through the progresses of human discovery, science, and invention. The mariner's compass, with its



points, and its magnetic needle (even after allowances for the variation of the latter, and for its constant *aversion* from the *true north,*) enables the seaman to steer his vessel through the darkest night, and when not a star, as he will tell us, is to be seen in all the sky!

4. In these maritime and northern countries, the pole-star, as a guide or leading-star, is of chief or distinguished present value in navigation. Our travel by land is so usually upon roads already laid out, that we think little of finding the places we are travelling to by help

of any heavenly body. It is still otherwise, however, upon those *seas* of *sand* which compose the deserts and steppes of Africa and Asia, and upon those *prairies* and *pampas* which the Indian crosses in North and South America. In North and South America, the warrior, hunter, and the traveller, thankfully direct, by the positions, as well as by the lights, of particular stars, and of the stars in general, their expeditions and most ordinary steps; and in Africa and Asia, the merchant and the pilgrim, lighted, cheered, and led by the same guides

(the stars,) pass over the widest solitudes, and, borne by their patient camels, arrive in safety at their shrines, their markets, and their homes; or the faithful messenger trots swiftly on his rapid dromedary. The guide-posts, by our road-sides, are sometimes of little use to such as *cannot read*, or to such as travel in the darkness; but the stars of heaven are always at *their* posts; and, besides pointing the way, they tell, even to the rudest or the worst provided of the human race, the hour of the night, and are lamps at the same time to their feet. The stars are the clocks, the flambeaux, and the guide-posts, and even guide-books, of the natural world. They light us, and they teach us *time* and *place*.

5. I have said something of ships at sea, and of caravans in the desert, preserving their way by starlight; and, besides that you know so well how much safer and pleasanter it is to travel by moonlight than without it, even to the next house, or on a gravel walk, we may think, for a moment, of the assistance of moonlight to the Laplander, journeying in his sledge

drawn by his reindeer, over long tracts of snow.

6. Nor is it men alone that travel or move about by moonlight. Many beasts and birds both seek their food, and perform their migrations into distant lands or seas, at those times when they have the advantage of the moon's light. Even the fishes in the seas and rivers often move and travel at the same seasons; though it is true, indeed, that by so doing they all expose themselves, sometimes, to danger. For, as to seeking food, men seek food by moonlight like themselves; and thus, in their own turn, they sometimes fall a prey. Several sorts of birds of passage travel by night, and choose moonlight nights for their motions. We sometimes hear their voices over our heads, when they are high above us, so that we can see nothing. Some of them, if confined, and contented at other times, are restless on moonlight nights, at the season of migration.

7. We have spoken of the Hunter's Moon;

and the Fowler, as well as the Hunter, shooting wild-fowl, is often busy upon moonlight nights. It is the same, also, with the Fisherman. Fishes are very fond of light, and of all things that are bright and shining; but the shining moon encourages the Fisherman to spread his nets;

for, then, the lively fishes, seeking their own prey, crowd into them, and fill them.

QUESTIONS.

1. Are the sun, moon, and stars, moving lights in the heavens? 3. Has the pole-star been otherwise called the lode or leading star? Is the magnet otherwise called the "load," or "lode," or "lead," or "leading stone?" Has the progress of discovery and invention diminished the importance of lights of the stars to mariners at sea? 4. Are the stars still of importance as guides among nations less acquainted with the arts? Do the stars light us, and enable us to distinguish the intervals of time, and the distances of the places?

CHAP. LXII.

SEAMEN'S OBSERVATIONS OF THE SUN, MOON, AND STARS. TAKING AN ALTITUDE OR MERIDIAN. KEEPING A LOG. VARIOUS CIVIL USES. HOURS AND DISTANCES, OR TIME AND SPACE.

1. EXCEPTING, as I have said, the pole-star, the stars in general enter into small daily account with us, in respect of their ministry to artificial uses. It was greatly otherwise, however, with antiquity; and is still so where the *artificial light* (the light of science) has penetrated less deeply than among ourselves.

2. As the progress of discovery, of science, and of invention, by the introduction of the magnet or loadstone, and of the magnetic needle, have made us independent of a *continual* sight of the pole-star; so the extent and precision of our modern acquaintance with the phenomena of the sun and moon, have lessened our dependence upon those of the stars and planets in general, and therefore withdrawn them from a large share of our attention.

3. It is to the sun and moon that we now

content ourselves with looking, in order to be taught chronology, geography, and hydrography; and when to plough, and when to ride and sail, and sow and reap. It is of these only that we are now content to ask concerning the years, and the months, and the seasons; nay, even the weeks, the days, and the hours of the day and night!

4. We know that from the stars in general we receive light and heat. We know that all of them are rising and setting, and all mingling, with those of the sun, their benign influences upon the earth, as well when the latter is present, and makes them invisible, as when it is absent, and they alone supply its place; but the profound knowledge which we now possess of the motions and influences of the sun and moon, and the vast superiority, both of appearance and importance, of those two luminaries, have diminished, age by age, our attention to our lesser friends the stars, and even to our near neighbours and fellow-travellers, the revolving planets!

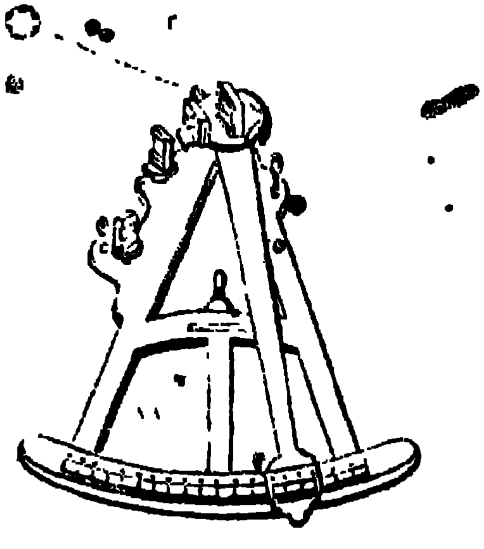
5. But the sun and moon remain indispensible to us (not wholly neglecting, however, the stars) as our celestial guides. Without repeating my references to other uses, I may again remind you of their importance to navigation, geography, to time-keeping, and therefore to chronology and history. By their help, and with the artificial help of his sextant, his charts, and his logarithms, the seaman determines, as well his *latitude* and keeps his *log*, and compares his chronometer; so that he

knows where he is, how far he has come, how far he has to go; how fast he sails, or has been sailing; how long he has been at sea; and what is the season of the year, the day of the month, and the hour that is passing. By their help, too, the geographer learns the situation and boundaries of countries, the position of cities, towns, and villages; of rivers, plains, and mountains; the hydrographer, the places and extent of seas, of bays, of capes, and of those rocks and shoals which it behoves the navigator to avoid; and finally, the astronomer, the chronologer, the horologer, the dialler, the clock and watch-maker, almanac-maker, and the world at large, to know all *time* in the universal, and all its natural evolutions;—cycles and centuries, years, months, weeks, days, hours, minutes, and seconds; and to calculate "*terms* and tides," (like the Schoolmaster in the Deserted Village,) holidays and eclipses, and all the events dependent or established upon those of nature—past, present, and to come!

6. My little readers will be able, from what I have now said, to form some notion of the great importance to the affairs of human life, not only of the existence of the Sun, Moon, and Stars, but of the human knowledge of their laws, and of all their influences upon nature, and capabilities of affording service.

QUESTIONS.

1. Do we still make many important uses of the lights of the sun and moon? 3. Which are the arts and sciences and occupations, in the pursuit and practice of which they afford us their assistance? 5. What of the uses of the sun and moon to navigation, geography, and time-keeping? What of the use of the sextant?



CHAP. LXIII.

ABOUT THE HABITABLENESS OF THE SUN, MOON, PLANETS, AND ALL THE STARS. ABOUT A PLURALITY OF WORLDS.

1. I HAVE told you before about the notion that there are people in the moon; and you will sometimes hear persons talk of two very different

things, concerning the heavenly bodies, as if, in reality, the one were the same thing as the other. They will sometimes talk of the question of the *habitableness* of all these bodies, and again of their composing a *plurality of worlds:* as if our agreeing to the first of those probabilities obliged us to agree to the other.

2. The doctrine of a plurality of *worlds* supposes all the heavenly bodies to be resemblances to the particular planet which we inhabit ourselves, and which we commonly call the *world;* that is, that they are inhabited and clothed with living things and vegetables like those of the *earth;* and especially that (like the *earth*) they are inhabited by men, women, and children. Now I have told you many things, and I could tell you a great many more, to show that the *earth*, or *the world we live in*, must have plants, and be *inhabited*, in a manner peculiarly its own; and that therefore there is no reason to believe in a *plurality of worlds*, meaning a multitude of heavenly bodies clothed and inhabited like ours.

3. It has sometimes been thought a subject for pious admiration, that the planets of our system, as they resemble our own in many important respects, should be intended by their all-wise and all-powerful Creator for the abodes of exactly similar living creatures to those of the earth; and that the same belief should be extended to the stars, and to the planets no doubt pertaining to those stars; that thus the vision might be indulged in, of a universe of races of mankind. But, since it is known how dissimilar in some important particulars, as well as similar in others, are the planets of the Solar System, and by analogy all the other stars and planets equally; I hold it to be more reasonable, more consistent with the truths of modern science, and at least equally a subject for pious admiration, to believe, that the all-wise and all-powerful Creator has filled the heavenly bodies with organic life as varied in form and in nature, though not more so, as is the physical condition of those inorganic bodies themselves.

4. I am too much impressed with the inexhaustible variety of the organic as well as general creation, even upon this single and small planet which is our own, and which we call the earth, to restrict, in my thoughts of the myriads of bodies which fill the heaven, and which, in themselves and their conditions, are certainly, at last, so essentially dissimilar to each other;—I am too much impressed, I say, with the amazing spectacle of the variety of creation, even upon this small and single planet of our own, to restrict, in my apprehension, the formation of the *inhabitants* of the other bodies to any single model.

5. But the simpler question of the *habitableness* of all the heavenly bodies, I decide in a very different way; as even what I have said upon the first question may have already induced you to suppose. That very *variety of creation* subsisting upon one single planet, where neither heat nor cold, nor light nor darkness, nor situation, nor separation, interfere to prevent the production of *life*, as well animal as vegetable,

over its whole surface—forbids me to doubt (even if I could doubt it without that testimony) that all the heavenly bodies are clothed and *inhabited* with plants and living creatures, each according to its circumstances!

CHAP. LXIV.

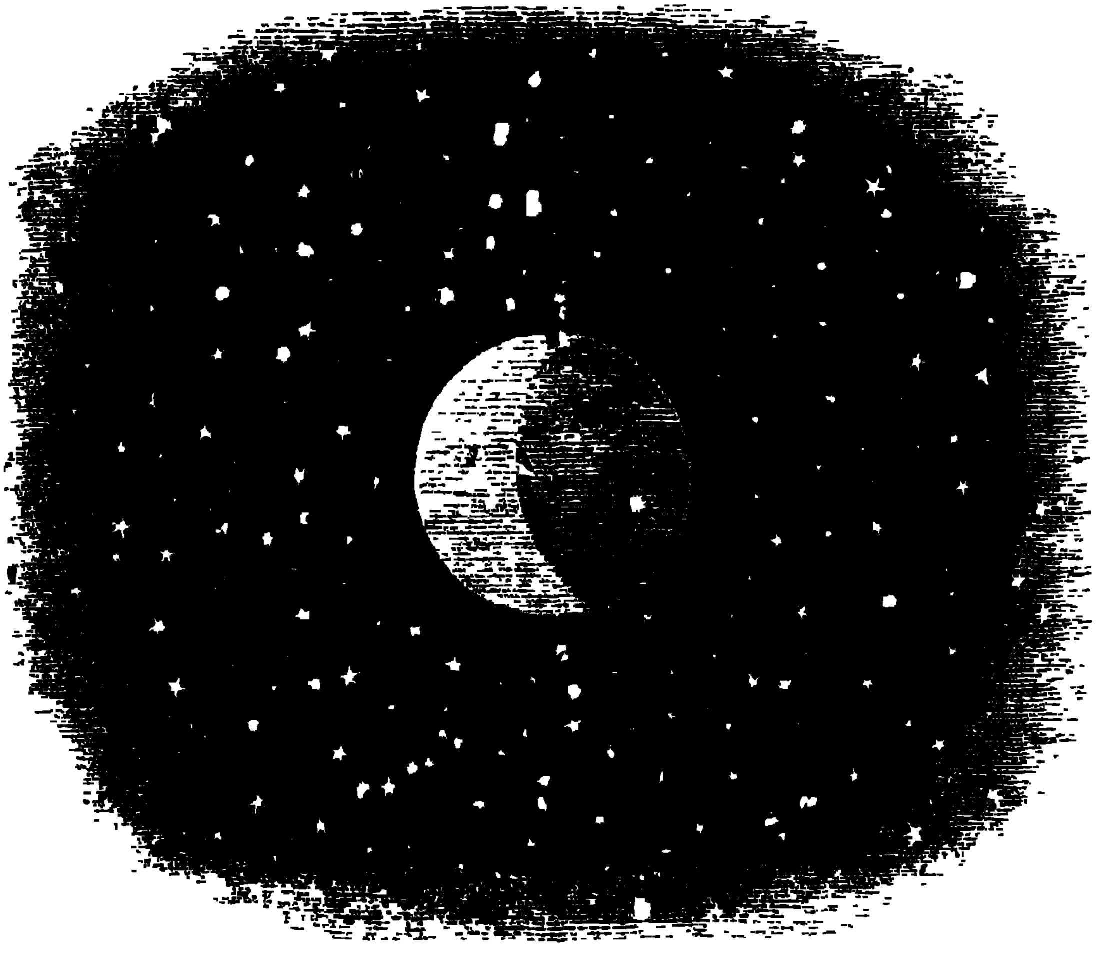
PARLEY TELLS ABOUT THE EARTH.

1. AT length, however, we have done with all our general view of the heaven, and even our general view of the Solar System, with the long list of its planets, comets, and its orbits, heavens, or spheres; and now (reposing, as it were, from contemplations so vast, and so widely spread) we may permit ourselves to talk exclusively and finally of our own small particle in the mighty space—the little planet of the earth!

2. Upon the next page is a picture of the earth, as we may faintly imagine it to appear, while pursuing its orbit, and while surrounded by the stars and planets.

3. You know that the earth is a vast globe or

ball, the surface of which is divided into land and water. You know that it is covered with seas, and oceans, and rivers, and mountains, and valleys, and plains.



4. You know that, as I have just now said, the earth moves in the heaven, with stars all around it. The people of one country, as well

as those of another, see stars above their heads. All the people of Europe, Asia, Africa, and America, see stars sparkling in the sky, as well as we.

5. Now, how far do you suppose it to be, around the earth? I will tell you. Suppose you were to take a rope and pass it quite round the earth, you would find that the rope would measure twenty-five thousand miles. So the world is twenty-five thousand miles around.

6. How far do you think it is through the middle of the earth? Suppose you could put a stick through the middle of the earth, as you can put a stick through an apple, how long must the stick be, to reach through? It must be eight thousand miles long.

7. If a man were to travel fifty miles a day, it would take him five hundred days to travel around the earth. It is impossible for a man to go through the centre of the earth; but, if he could do so, and should travel fifty miles a day, it would take him one hundred and sixty days to pass through it.

8. That the earth, in the meantime, is really round—that is, really a globe or sphere, or like a ball—has always been found very difficult for mankind to understand; and, though many of the most ancient philosophers believed it, many wholly rejected the doctrine, and made it the subject of their ridicule. It must easily seem, indeed, very incredible, that men should as much exist upon one side of a ball as upon another, as we see the figures in this picture.

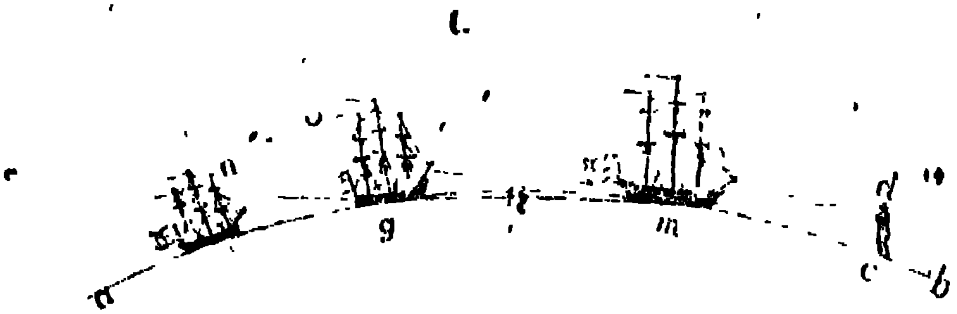
9. It might seem strange, even if we thought only of trees and plants thus apparently topsy-

turvy; but stranger still, that men and beasts, and even loose stones, should move and rest with safety upon all parts of this circular outline; and accordingly an ancient philosopher compared the men whom he was told so moved, to crabs hanging by their claws. But the whole is confirmed by facts, and explained by the philosophy of the *attraction of gravitation.*

10. All bodies, on or near the earth's surface, have a tendency, or seeming inclination, to descend towards its centre or middle part. It therefore follows, not only that the two figures in our picture are both attracted to the centre of the globe; but that if each of them should drop from his hand an orange, or any other object, each object, though otherwise in opposite directions, would fall or *gravitate*, and be *attracted*, toward the centre of the globe, and thus remain upon it.

11. A few words more, however, on the figure of the earth. The navigators who have sailed round the world have proved, that in one direction at least, viz. from east to west, the earth is

round; but still it has been thought by some, that it is not so from north to south. But this is a very mistaken notion, as I hope to show you by the help of this diagram. Let the line *a b* represent a portion of the earth's surface, *c d* a spectator looking along the surface of the ocean.



12. If, now, a ship should come in sight, her top-masts would just be seen along the line *d n*, as at *n*: when she approached to *g*, the lower sails would be visible to the spectator; and when she arrived at *m*, he would see the whole vessel.

13. Now this would be the case in whatever direction the vessel might be sailing, which is a very satisfactory proof that the earth is of a globular form.

14. How large, then, is the earth! When we

come to the foot of a mountain, and look up and behold it, its magnitude fills us with awe and wonder; but the largest mountain is a mere speck, compared with our vast globe!

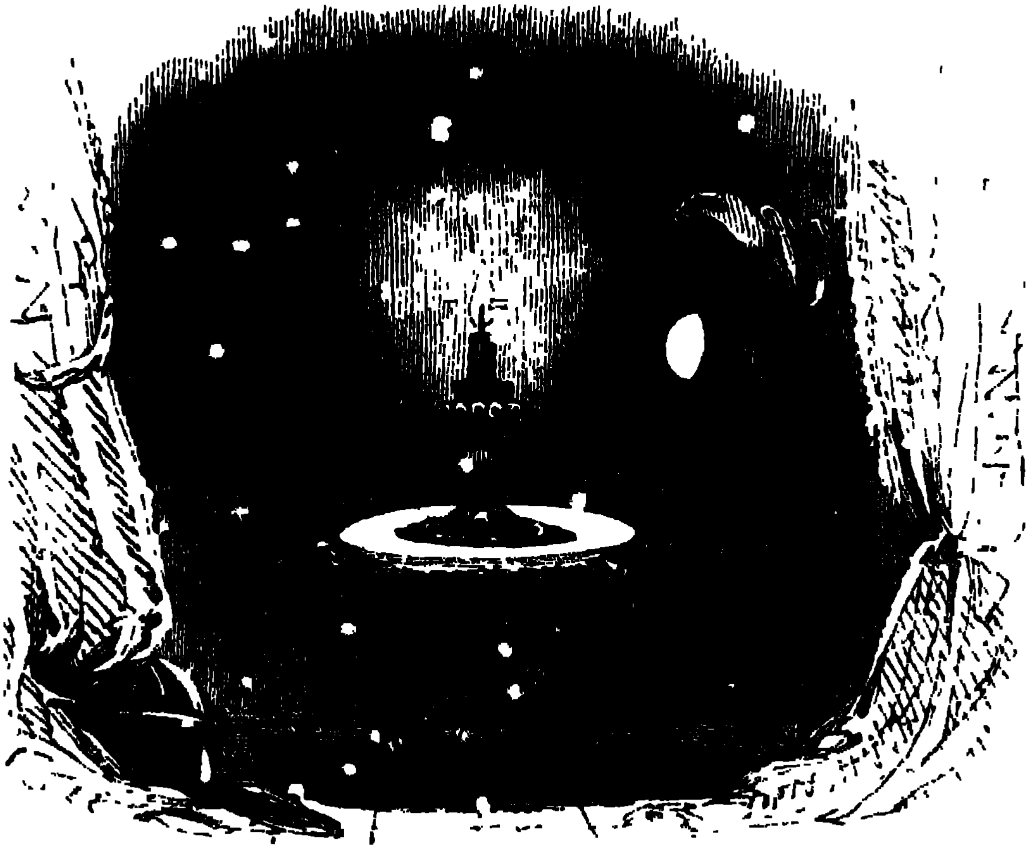
15. But, large as the earth is, the stars, which twinkle in the heavens, and appear to us so small, are immeasurably larger than the earth, as I have told you. Look up at one of the stars in the sky, and imagine yourself upon it. The earth, dwindled by the distance, would be entirely invisible.

QUESTIONS.

3. What is the earth? With what is it covered? 4. What is the situation of the earth? Do the people on the other side of the earth have a sky and bright stars over them as we have? 5. How long must a rope be to reach round the earth? 6. How long must a stick be to reach through the earth?

CHAP. LXV.

SOMETHING ABOUT THE EARTH AND THE SUN.



1. WE say, the sun rises in the morning, and sets at night. The sun appears to rise and set, but it does not. The sun is stationary, or nearly so. That is, it remains always in the same spot, or nearly in the same spot, in the heavens.

2. But you will say, The sun does rise and set, for I have seen it. Not so fast, my little boy! At the beginning of the chapter is a picture of a candle and an apple. The candle shines upon the apple just as the sun shines upon the earth. The candle shines upon but one side of the apple at a time. So the sun shines upon but one side of the earth at a time. Where the candle does not shine upon the apple it is dark. Where the sun does not shine upon the earth it is dark, and we call it night. If the apple were to be turned round, the sun would shine upon the other side. The earth turns round, and the sun shines upon the other side.

3. Thus, it is the earth that moves, and not the sun. It turns quite round once in twenty-four hours. We cannot see its motion, yet it is really in constant activity. It turns from west to east, and whirls around with almost inconceivable velocity. Strange as it may seem, we each of us are hurried from west to east, by this motion of the earth, at the rate of near one thousand miles an hour!

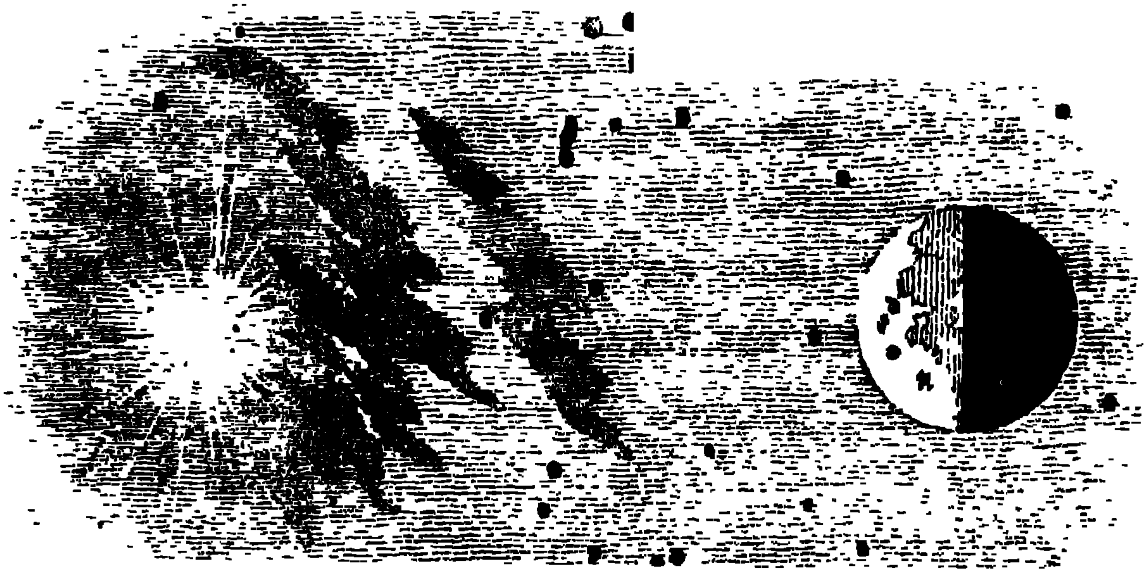
4. You will remember, that when it is noon where you are, it is midnight on the opposite side of the earth. You will remember that the earth never stops on its course. With uninterrupted motion it rolls on, day and night. The illuminated part of the earth is continually changing, with a motion from west to east. On one side of the earth, the hills and valleys are lighted up with the beauties of morning; on the opposite side of the earth, the shadows of night are perpetually advancing from east to west, covering the land and water with gloom.

QUESTIONS.

1. Does the sun rise and set, or not? 2. Why does the sun appear to rise and set? 3. How often does the earth turn round? Which way does it turn? Where does the sun appear to rise? Where does it appear to set? How many miles an hour are we carried by the motion of the earth, from west to east? 4. When it is noon here, what time is it on the opposite side of the earth? Does the earth ever stop?

CHAP. LXVI.

PARLEY TELLS ABOUT DAY AND NIGHT, AND ABOUT THE FOUR SEASONS.



1. THE light of the sun is spread around it in all directions; these rays fall upon that side of the earth toward the sun, and there produce daylight, or what we commonly call *day*.

On that side of the earth which is opposite to the sun, the rays of light do not fall; and there it is night. The foregoing picture will enable you to understand this subject perfectly.

2. Now the earth is constantly turning round, and day and night are therefore constantly succeeding each other. Thus you perceive that day is created by the light of the sun. Night is caused by the absence of the light. The succession of day and night is caused by the daily revolution of the earth on its axis.

3. You have often heard of spring, summer, autumn, and winter. Spring, you know, is the beautiful season of flowers. Summer is the season of fruit. Autumn is the time of harvest; and Winter is the season of snow and ice.

4. Now what should cause these changes of the seasons? Why is it not always winter, or why is it not always summer? I will endeavour to answer these questions.

5. Did you never observe, that in summer, the sun appears to be nearly over your head at noon? Look at your shadow in a summer's

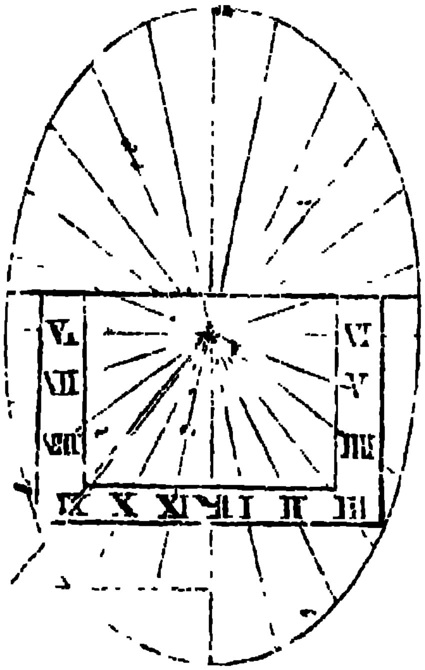
day at noon, and see how short it is. How different is it in winter! If you will observe the sun at noon in winter, you will see that it is very low in the sky, and your body casts a very long shadow.

6. Well: in summer then, the sun is said to send down its rays nearly in a perpendicular manner; while in winter it sends them to us in a very oblique, or slanting direction.

7. Now you will take notice that the rays of light and heat which fall upon an object in a perpendicular manner, are much more powerful than those which fall upon an object in a slanting direction. Thus it is, that the perpendicularity of the rays of the sun causes summer, while the slanting of the rays of the sun causes winter; or, these, at least, are a part of the causes. Spring and autumn are between winter and summer. The sun's rays do not fall upon the earth during these seasons, either in a perpendicular, or a very slanting manner. The seasons are therefore neither as hot as summer nor as cold as winter.

QUESTIONS.

3. What is Spring? Summer? Autumn? Winter? 5. Why is your shadow short at noon in summer? Why is your shadow long at noon in winter? 6. In what manner do the rays of the sun fall upon the earth in summer? In what manner in winter? 7. Which causes the most heat, oblique or perpendicular rays? Which causes summer? Which winter? How do the rays of the sun fall upon the earth in spring and autumn? Why are not spring and autumn as cold as winter, and as hot as summer?



CHAP. LXVII.

ABOUT THE LENGTHENING AND SHORTENING OF THE DAYS.

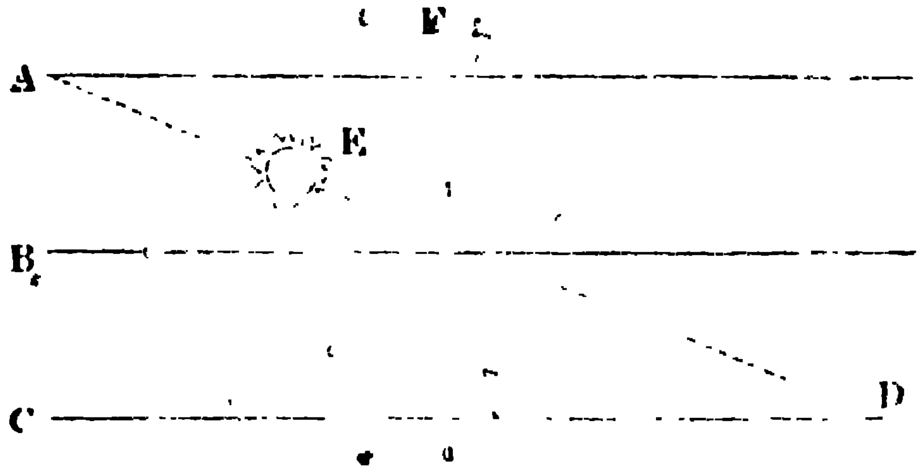
1. BUT, every year, as the year goes round, you see, and you hear it said, that the *days* (that is, the times of *day-light*) are either growing longer, or growing shorter.

2. Now, as the sun is always shining, and as the earth is always going round the sun in its orbit, and always performing its own rotation upon its axis; perhaps nothing that I have yet said has been sufficient to explain to you, how there should be differences in the lengths of the days; or how, even in the same parts of the world, the times during which the earth, in every twenty-four hours, receives daylight, are not, in all seasons, the same.

3. You will remember, then, that it is day, or day-light, only so long as the sun is above our horizon; that is, only so long as our part of the earth is turned toward the sun. But it will thence follow, that the same cause which

produces the variation of the seasons throughout the year, produces also the variations of daylight throughout the day.

4. If, in the following figure, you consider the two lines A and C as representing the two tropics, the line B as representing the equator, or the equatorial or equinoctial line; the dotted line D as representing the ecliptic, or line of the zodiac; the circle E as representing the sun; and the point F as representing the situation of the British Islands upon the globe, I think this will enable you to understand the lengthening and the shortening of the days.

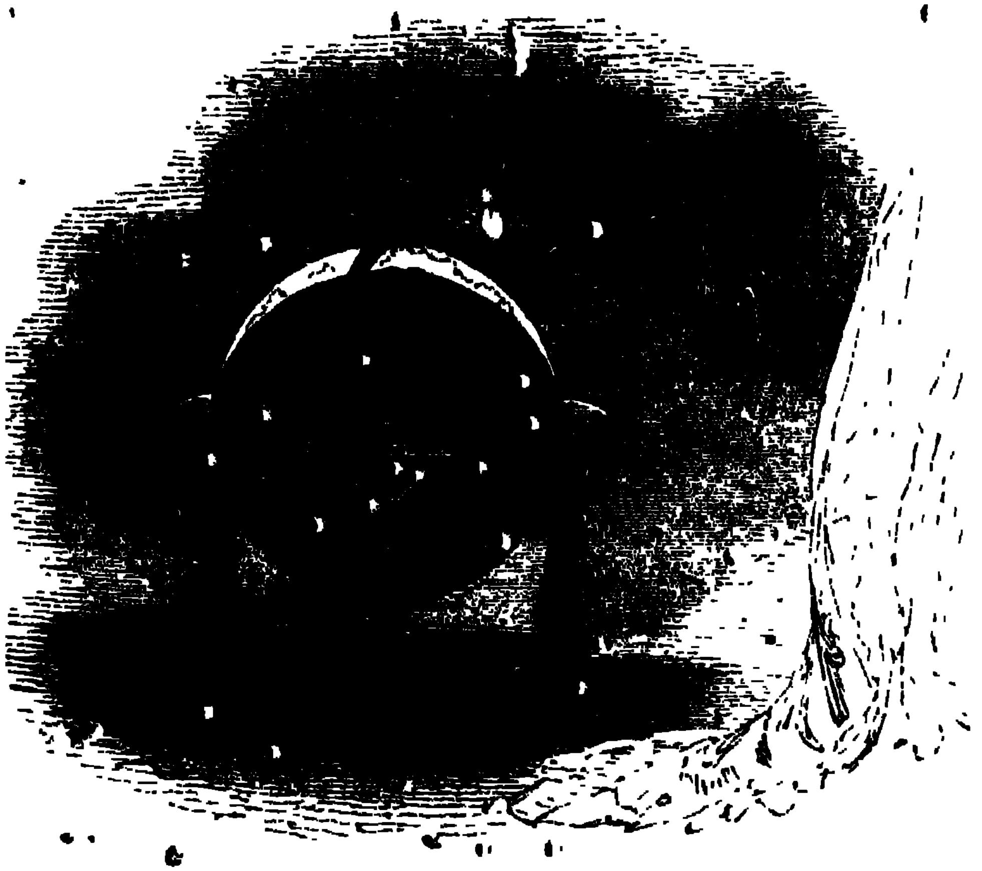


5. You have learned already, that the sun, E, is always travelling, or appearing to travel,

upward or downward, along the ecliptic, or dotted line E. You observe that the situation of the British Islands, F, is far to the northward of even the Northern tropic, A; and therefore far to the northward of any part of *the sun's path*, or of that part of the earth which is ever directly exposed to the sun's heat and light. You see, that in my figure, that season of the year is supposed, in which the situation of the sun in the zodiac, or upon the ecliptic, is to the northward of the equinoctial line B; and you can understand, from what we have already said about the zodiac, that, in the different months or seasons of the year, its place is in all the other parts of the same line. Now, you need not that I should tell you, that though the sun never comes nearer to the British Islands, F, than the line and point A; yet the nearer it comes to that line and point, the more of its heat and light will be felt at the point F; and the further it is off, the less. But this question affects only the seasons of the year.

6. From the same spherical figure of the

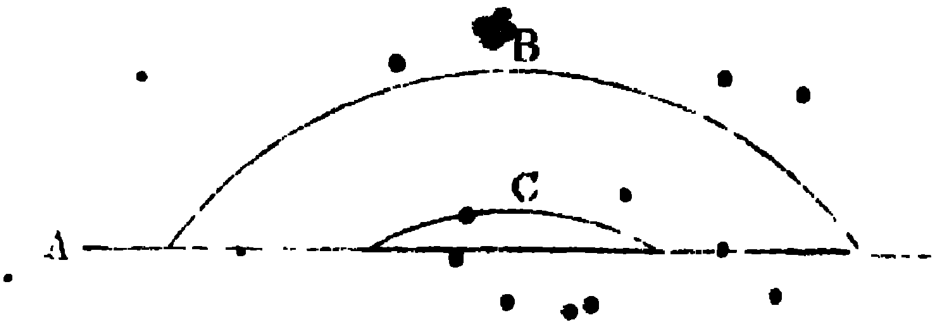
earth, however, which thus confines to the tropics what we call the path of the sun, it also follows, that the nearer the sun is to the northern tropic, the longer, in each day, or each rotation of the earth upon its axis, it will be seen above the horizon, in any parallel of northern latitude; and therefore the longer at the point F, or situation of the British Islands.



7. We have before us a terrestrial globe; and

I beg you to recollect, that upon whatever part of the globe you are, your situation is that of the letter F, or place of the British Islands, upon the summit of its circular edge, as here marked. It will follow, that the higher a lamp or candle is held toward the point F, the *longer* that point, during a rotation of the globe, (that is, during any one *day*,) will enjoy its light and heat.

8. Again: if, in the following figure, you call the line A the horizon of the British Islands;



then, in proportion as the sun, in its yearly changes of place, approaches or retires from that horizon, the longer or the shorter space will it be above it, during each daily rotation of the earth; because by rising higher, or sinking lower, it passes over a wider or a narrower *arch* in the heavens, and the *time* is always proportioned to the *space*. Thus, if, at Midsummer, the sun is so near, or so high, as to describe the arch B, over the horizon A; and at Christmas, so far off, or so low, as to describe only the arch C; then it must be plain, that it is not only further from the British horizon A, but is also a shorter time above it; causes, at once, both of less heat, and of shorter light, or days.

9. As to the increasing heat of spring, and highest heat of summer, these are caused, partly, as I have before told you, by the greater perpendicularity of the sun's rays, (a consequence of its greater nearness,) and partly by the length of the days, or greater length of time which, in every rotation of twenty-four hours, it is above the horizon of our part of the earth; that is, the higher and wider that *arch* in the heavens which it traverses daily between its rising and its setting, the more heat, and longer light.

10. From these remarks, my little readers, you will the better understand what is said of

an *arch*, and of a *vault*, (which is another word for an *arch*,) in the descriptive lines that follow:—

'Tis pleasant to the mind, the thought
By opening January brought,
That now the hasty-footed Sun,
On *vault the most depressed* (c) has run
His *briefest course*: that, day by day,
His track, about the heaven's highway,
Will form a *wider*, *loftier arch* (B);
And earlier, to attend his march,
Call forth the slumbering Hours, nor leave
So soon to rest, the shadowy Eve!*

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* The British Months. By Dr. Mant, Lord Bishop of Down and Connor.

CHAP. LXVIII.

PROGRESS AND PROSPECTS OF THE MODERN KNOWLEDGE OF THE SUN, MOON, AND STARS. SIR JOHN HERSCHEL'S RECENT ACCOUNT OF THE SOUTH CELESTIAL HEMISPHERE. HIS FORMAL DECLARATION AGAINST HIS IMPUTED "LUNAR DISCOVERIES."

1. A KINSMAN of one of the most distinguished English astronomers of his time, was asked by a lady (herself no mean proficient in the science of the stars,) "Whether Sir ——

had made any recent discoveries of importance?" "Why no," was the answer given; "and, indeed, he has rummaged the heavens so thoroughly, that I don't fancy there is much left for *anybody* to find out."

2. My little readers must pardon this rather odd employment of the word *rummaged*, by the answerer to the lady's inquiry concerning Sir —— —— (I would call him by his name if I were sure of it,) and only take notice of the opinion expressed; namely, that there is not much left among the stars "for anybody to find out."

3. Now this is an opinion too common upon most subjects, and one against the adoption of which I particularly wish to warn my little readers. For my part, I would not undertake to say, how many new things, even in the way of the Sun, Moon, and Stars, some of my little readers themselves may find out, when they grow bigger, if they are clever and active; and especially if, not content with all that they can read in books, or hear from those who

talk, they take care to look at the Sun, Moon, and Stars with their own eyes, and study them with their own understanding! I wish all my little readers, upon the one hand to *inquire*, and upon the other hand to *think*; for they may depend upon it, that there is plenty of everything yet to learn, which nobody is yet able to tell them; and, among the rest, plenty about the Sun, Moon, and Stars!

4. The skies are not hitherto even fully surveyed, any more than they are fully studied; and especially we have yet much to learn about the treasures of the South Celestial Hemisphere, which are not to be seen on our part of the earth. Of those treasures, as viewed in the regions of the equator, and of the tropic of Capricorn, an account has been recently given by Sir John Herschel, in a letter from the Cape of Good Hope, to Sir William Hamilton, Astronomer Royal for Ireland.

5. "I have swept," says Sir John, "over all, or nearly all, that part of the heavens which is invisible, or hardly visible, in England; except

just in the immediate vicinity of the Pole (a most barren region,) and (favoured by a season of almost uninterrupted clear sky, and a definition and tranquillity of the stars, under great apertures and magnifying powers, which I want language to express) have amassed a large collection of nebulæ and double stars of all classes, orders, and degrees. The general aspect of the Southern circumpolar region is in a high degree rich and magnificent, owing to the superior brilliancy and larger development of the Milky Way; which, from the constellation of Orion to that of Antinöus, is in a blaze of light, strangely interrupted, however, with vacant and almost starless patches; while, to the North, it fades away, pale and dim, and is, in comparison, hardly traceable.

6. "I think it is impossible to view this splendid zone, with the astonishingly rich and evenly-distributed fringe of stars, of the third and fourth magnitudes, which form a broad skirt to its Southern border, like a vast curtain, without an impression, amounting to a conviction, that the Milky Way is not a mere

stratum, but an annulus;' or, at least, that our system [the Solar System] is placed within one of the poorer and almost vacant parts of its general mass: and that eccentrically, so as to be much nearer to the part about the Cross, than to that diametrically opposed to it.

7. "The two Magellanic Clouds are very extraordinary objects. The Greater is a congeries of stars, clusters of irregular form, globular clusters and nebulæ, of various magnitudes and degrees of condensation; among which is interspersed a large portion of irresolvable nebulæ, which may be, and probably is, star-dust, but which the powers of the twenty-feet telescope show only as a general illumination of the field of view, forming a bright ground on which the other objects are scattered. Some of the objects in it are of very singular and incomprehensible forms; the chief one especially (30 Doradûs,) which consists of a number of loops, united in a kind of unclear centre or knot, like a bunch of ribands disposed in what is called a true-lover's knot. There is no part of the heavens where so many nebulæ and

clusters are crowded into so small a space as in this 'cloud.'

8. "The Nubecula Junior is a much less striking object. It abounds more in irresolvable nebulous light, but the nebulæ and clusters in it are fewer and fainter, though immediately joining to it is one of the richest and most magnificent globular clusters in the hemisphere.

9. "The great nebulæ in Orion and η Argi are, however, by far the most surprising objects this hemisphere presents. The former appears to much greater advantage than in our latitudes, and presents many appendages, branches, and convolutions, which are not discernible in its low situation in Europe.

10. "I cannot trace in η Argi, as seen in the twenty-feet, any resemblance to the figures published of it. It is of immense extent, and crowded with stars, to which the nebulæ form a brilliant back-ground.

11. "The planetary nebulæ of the Southern circumpolar sky are numerous and highly characteristic. I have discovered no less than five,

quite as sharply terminated in their discs as planets, and of uniform light.

12. "You may form some idea of this climate, as regards clearness of sky, from what was told me by our provisional governor, Colonel Bell: —viz. that out of forty-two successive days, he had only three times been disappointed in finding Venus, with the naked eye, in broad sunshine (at 9 A. M.)! I read, with ease, a few nights ago, the most involved parts of a lady's closely-crossed letter by the light of *an eclipsed moon*, then near the zenith—certainly, the eclipse was not a great one!"

13. I may mention further in this place, that under date of the month of September, 1836, Sir John has made the following formal declaration concerning his imputed discoveries in the moon: "I take this opportunity to state, that I have no knowledge of, or participation in, the absurdities attributed to me under the name of 'Lunar Discoveries.'—J. F. W. HERSCHEL." *

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* See Athenæum, No. 483.

CHAP. LXIX.

PARLEY TELLS ABOUT TELESCOPES. ABOUT MICROSCOPES. ABOUT THE GENERAL WONDERS OF CREATION.

1. I SUPPOSE you have seen a spy-glass? It is an instrument, as you know, for seeing distant objects more distinctly. Suppose there is a house at the distance of four or five miles from you. With the naked eye, it looks exceedingly small; you cannot distinguish the chimney, or even the windows. Now, if you take a spy-glass, and look at this house through it, the house appears to be much nearer and larger; and you can easily discern the chimney and the windows.

2. The moon and stars are so very far off, that a spy-glass will assist you but little in looking at them. But if you will take a telescope, which is a very powerful instrument formed on the same principles as the spy-glass, and direct it to the moon, or to the stars, then they will appear very large.

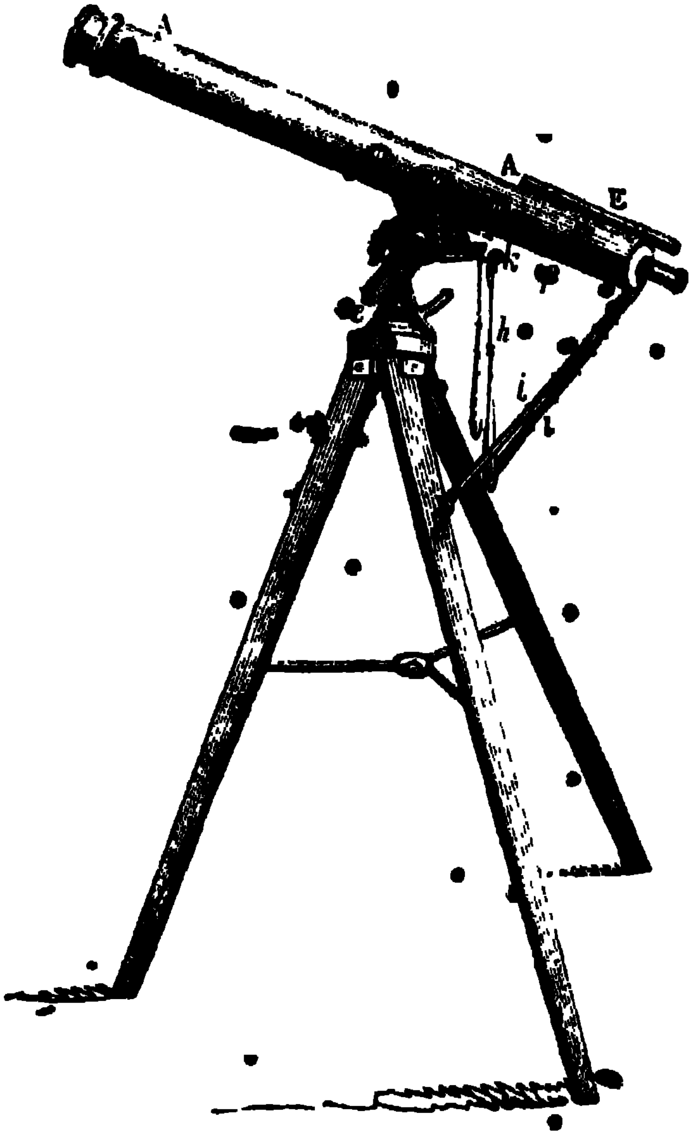
3. I have told you of some of the discoveries

made by means of telescopes. Many thousands of stars and other celestial objects are found to exist far beyond those we can naturally see in the sky; and there is reason to believe that, still beyond these, there are millions and millions of others.

4. The picture at page 261 represents Sir William Herschel's great telescope, erected in an open yard, at Slough, near Windsor, and made at the charge of King George III. Its tube is forty feet in length, and four in diameter.

5. On the next page is a picture representing an achromatic telescope, after the construction of Dollond, the philosophical instrument-maker. It is named from the excellent invention of that gentleman, by which the defects of the common telescopes, in fringing the object viewed with the prismatic colours, is removed. The one now before you is of the very best description, having all the motions produced by fine rack-work, and possessing a magnifying power of two hundred and fifty times. The two handles, *h*, are for moving

the rack-work in setting the instrument; the sliding tubes, *i i*, are for the purpose of steadying it; and the small tube, E, is called



the finder, its use being to find the object more readily than can be done by looking through the large tube, A A; the eye-glasses all fit into the brass tube, D, which is made to move out or in at pleasure, to adjust the distance between them and the object-glass, so as to suit any sight.

6. Such are telescopes; and so great, as you have seen throughout my book, are the helps they give us for our discoveries in the heaven. But they are useful also (and as I have given you reason to know) for our surveys upon the earth. And the earth, my little readers, has its wonders, no less than the heaven; and *microscopes* can show them to us as well as telescopes!

7. But I draw to the end of my Tales of the Sun, Moon, and Stars; and I would not leave you with any exaggerated thoughts of the admirable nature of the objects of this branch of study. I would not have you, in any sense, pay so much attention to the skies, as to overlook the things of the earth; and thus, like the philosopher of whom you have heard, be in danger of falling into a well at your feet, while thinking of nothing but the stars.

8. Creation is so admirable throughout, that we are in the wrong to praise any one of its parts, to the slighting of the rest. I often think, what a marvellous, what a miraculous creation it would still be, did it contain nothing but insects, or even nothing but animalcules! While, as to men, beasts, birds, fishes, and herbs and flowers, all these come nearer to our hearts than stars; and, is any one of them less admirable than the mightiest star?

CHAP. LXX.

THANKS TO ILLUSTRIOUS ASTRONOMERS AND MATHEMATICIANS. NEWTON AND HIS DOG DIAMOND. HISTORY OF JAMES FERGUSON. HIS POVERTY AND SELF-EDUCATION. KING GEORGE THE THIRD SEEKS TO BE INSTRUCTED BY HIM IN ASTRONOMY. POSSIBLE INFLUENCE OF THE EARLY GENIUS AND INDUSTRY OF FERGUSON, UPON ALL THE SUBSEQUENT PROGRESS OF ASTRONOMICAL DISCOVERY IN EUROPE, TO THIS DAY. LOVE AND PATRONAGE OF ARTS, SCIENCES, AND LETTERS, BY KING GEORGE THE THIRD. HIS INFLUENCE UPON ASTRONOMICAL RESEARCH.

1. WITH respect to all that in these pages I have told you, what thanks do we not owe to the industry and genius of so many illustrious astronomers, ancient and modern, dead and living, English and foreign? What should we have known, if we had been left to look at the heavens by ourselves, and denied the help which has been afforded us, of all the wisdom accumulated through ages upon ages?

2. It would have pleased me, had my book been large enough, to repeat many of the names to which we are so much indebted; with additions, to several of them, of remarkable pas-

sages in their history, either personal or scientific. But I content myself with offerings of this kind to two alone, parts of what I shall relate of whom has the advantage of conveying even more general lessons, with strong claims on your esteem.

3. The well-known anecdote of Sir Isaac Newton and his lap-dog Diamond, shows with what serenity men so laborious and so eminent as Newton, can sometimes bear, not with the severest mortifications only, but also with the heaviest misfortunes, as to their pursuits!

4. Sir Isaac, upon a quantity of paper, had set down long trains of the most arduous astronomical calculations; and the paper lay upon his table. But he had a favourite little lap-dog, whose name was Diamond; and, one day, in his absence, the unlucky dog contrived to throw down so much ink upon the papers as wholly to obliterate their contents. Those contents were so intricate, and had been produced with so much labour, that Sir Isaac, upon the discovery of the accident, at once renounced all idea of

restoring them; yet he contented himself with saying to Diamond, "Ah! Diamond, Diamond, you little know what mischief you have done!"

5. But I shall mention briefly the name of Ferguson, because, besides that Ferguson was an eminent astronomer, his history shows how much even young star-gazers may do for themselves, in the way of study, if they have but genius and application!

6. Ferguson was a poor boy, who, in his whole life, never received above a half year's teaching at school; and who yet lived to attain to the highest eminence in astronomy and mechanics.

7. Being put into the occupation of a shepherd boy, his nights were spent in studying the stars; while, in the day-time, he made models of mills and spinning-wheels. When his day's work was over, wrapping a blanket or a plaid

about him, he went into the fields, where, stretching a thread, with small beads upon it, he slid the beads till they hid particular stars from his eye; and then, laying down the thread upon a piece of paper, he marked the stars upon it according to their respective positions.

8. When he was grown up, he wrote and lectured upon astronomy. George the Third, before his accession to the crown, attended Ferguson's public lectures, and long received him in private, for instruction in astronomy, and in all the parts of experimental philosophy. During the first period, he made Ferguson occasional presents of money; and, when he became king, he assigned him a pension of fifty pounds a year, out of the privy purse.

9. I indulge in a speculation, where, if I am wrong, my little readers must forgive me, for the sake of my recollections of what I learned to value when I was little like them, and have valued ever since. They must forgive me for the sake of my admiration of the talents, the application, and, above all, the good example of

Ferguson; and of my hearty veneration for the memory of good old King George!

. 10. I think that the progress of astronomical discovery, and even of astronomical science, throughout Europe, during seventy or eighty years, may have absolutely received its impulse through the Scotch shepherd-boy Ferguson, and the communication of his ardour to the mind of him whom he first knew as the young Prince George of Wales; and still more strongly do I entertain the notion, that at least through that Prince's regard for astronomy has occurred the progress of which I have spoken.

11. It may be uncertain whether Ferguson's lectures first awakened the curiosity of the then young Prince George, concerning the Sun, Moon, and Stars; or whether the royal pupil attached himself to Ferguson because of his previous curiosity about the stars. At this point I am in doubt; but what followed was the royal patronage of the astronomical pursuits of the German Herschel, another self-taught astronomer, who (as is well known)

came to England only as a musician in a regimental band; then, Herschel's observation of the Nebules and Double Stars, and discovery of the great planet which he called Georgium Sidus; then, the eagerness of foreign astronomers for further discovery; then, the discovery of the little planets, by Piazzi, Olbers, and others; and in the midst of all this, the great scientific computations of Lagrange and the Marquess de la Place; the latter the son of a farmer, as Ferguson had been a farmer's servant. George the Third ascended the throne in the year 1760, and Ferguson died in the year 1776; and when my little readers shall hereafter know the dates of the lives and writings and discoveries of all the modern benefactors to astronomy, they will find the whole belonging to years more late than 1760 and 1776!

"12. But there is one thing, at any rate, quite certain. It is, the love and effective patronage of George the Third, for arts, sciences, and letters; the study of the Sun, Moon, and Stars inclusive. I say nothing of the zeal of that magnanimous Prince for husbandry, nor of his devotion to other pursuits and concerns of human life, either the most honourable, the most innocent, or the most practically beneficial to his people, and to mankind; but I must tell my little readers that George the Third, besides patronizing, and aiding with his purse, the shepherd-boy Ferguson, and the German band-player Herschel, as to astronomy, patronized and employed West, the historical painter; founded the Royal Academy; and collected *two* extensive libraries, both of which are now in the British Museum, and in daily use for the general advancement of letters: the first given by himself in his lifetime, and the second given by his son, King George the Fourth. I sometimes go to the British Museum, to read, and to take my notes, so as to learn there myself a part of what I teach to others; and when a book is brought to me, though not out of what is particularly called the

King's Library, it is ten to one but I find the name of the benefactor upon its cover, and to whom I and those that listen to me owe what I tell them, stamped, in its golden letters, thus:—"The Gift of King George III."

13. Such, then, my little readers, are some of the claims of the pursuits of the good old English King,* to glorious and affectionate remembrance; and such (in respect of our present knowledge of the Sun, Moon and Stars) is, by possibility, our united debt to the royal student and patron, and to the poor and uneducated, but ingenious and assiduous Scottish shepherd-boy!

14. But oh! if I could now but dare to add, to this fond dream of mine concerning the influence of Ferguson and his boyish days upon the tastes and fame of George the Third, a dream still fonder as to myself; what a finish to my final chapter! I mean the dream that Peter

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* "Born and educated in this country," said George the Third, in his speech at the opening of his first Parliament; "born and educated in this country, I glory in the name of Briton."

PARLEY, in his own humble turn, may chance, by his humble pages, to waken the lasting thoughts, if not of a young Prince or Princess, yet of some gay or serious child or other; making of some boy a future Ferguson, or of some girl a Barbauld or a Somerville!

JAMES FERGUSON.

CONCLUSION.

1. I HAVE now told my little hearers a great many Stories. I have told them about Europe, and Asia, and Africa, and America, and about the Sea; and about England, Scotland, Ireland, and Wales, and several other things.

2. It would give me great pleasure to know that my little readers have all of them been pleased with these Stories. To an old man, that is now gray and lame, it would be a matter of delight, to see, as he hobbles about, in the bright faces of the little boys and girls, a smiling "Thank you, Mr. PARLEY; thank you for your Stories!" But, to tell you the truth, I have a graver wish than this. I have sought to give you pleasure, but I am more anxious yet, to make you wise and good! All that makes you wiser, should also make you better; and I hope that you will never have out of mind, that to be happy it is required to be good, and that if you are bad you will be miserable!"

3. I must now bid you farewell. Though I am thinking to write still more Stories for you, it may be that we shall not meet again. So, my dear little listeners, if that is our lot, farewell, and God bless you!

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